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(71)(72) Applicants and Inventors: NUTTALL, David, J., H. [GB/US]; 20634 N.E. 181 Place, Woodinville, WA 98072 (US). BREHM, Bertram, G. [US/US]; 25119 N.E. 18 Street, Redmond, WA 98053 (US).

(74) Agent: SLEATH, Janet; Stoel Rives Boley Jones & Grey, 600 University Street, 36th Floor, Seattle, WA 98101-3197 (US).

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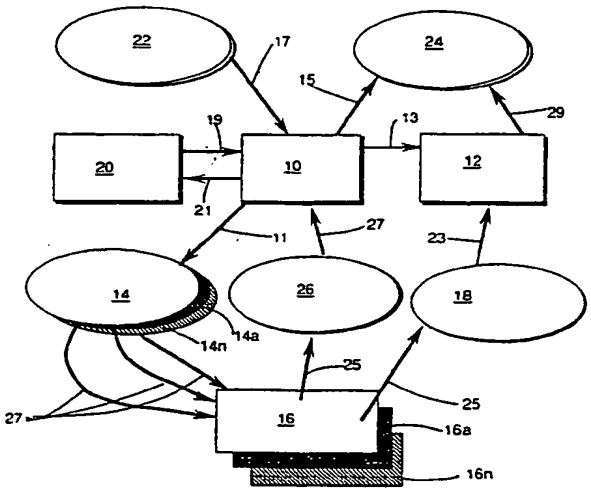

(57) Abstract

An information model based on a physical system, such as the physical equipment in a power system. An object-oriented information model provides a generic power system model that may be applied to any of several specific applications. In the invention, physical pieces of equipment are represented as objects with attributes that can be verified (primary data) and relations including connectivity, grouping, and location. The model handles all known configurations of power systems and is extensible to new configurations. Attribute input is supported from primary sources and is used to calculate data required by applications programs. A window-based graphical user interface uniquely simplifies operation of the database. Thus, the present invention provides a single, easy to use, source for all proprietary application databases at a utility.

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INFORMATION MODEL BASED ON A PHYSICAL SYSTEM

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

The present invention relates to object-oriented systems analysis. More particularly, the present invention relates to an object-oriented information model based on an underlying physical system, including associated infrastructure and personnel, for example the equipment which makes up an electric utility power system.

2. DESCRIPTION OF THE PRIOR ART

Electrical power systems are large complex physical systems with many types of interconnected electrical equipment. Such systems are often modeled for various reasons within the departments that make up the utility which is responsible for operating the power system.

Each department within the utility typically maintains its own specific database, usually employing a proprietary application program. This proprietary application program

is tightly coupled to a particular operating system, computer manufacturer, data structure, etc. That is, the proprietary application programs employed in the various departments of the utility are vendor specific and cannot be interfaced with or exchange data with the application programs used in other departments (and often with those within the same department). Thus, in a utility, information is not freely exchangeable between the various departments of the utility, such as planning, engineering, operations etc.

The present state of the art is such that the various proprietary application programs are, at best, difficult for a department to use and maintain. That is, the user interface in most such programs requires the manipulation of strings of raw data, or the entry of data into crude forms. Thus, highly skilled personnel are required for the performance of a tedious and repetitive task.

Additionally, known database structures as are employed in such application programs merely provide virtual models of a power system based on abstract mathematical descriptions of system equipment. Such models are generic approximations of actual installed equipment within the power system. Thus, there is an inherent error in the model. When the error that is present in several separate databases within the utility is considered, it can be seen that the cumulative error renders data collection and reporting within a utility a Tower of Babel.

Accordingly, the utility is faced with occupying its personnel with the many problems attendant with such application programs: redundant entry of the same data in different formats, inconsistent and inaccurate local

departmental models, stale data as information within one department does not track other departments, slow response on a system level to equipment changes, etc., all in the context of many complex application programs that are difficult and expensive to use and maintain.

SUMMARY OF THE INVENTION

The present invention is an object-oriented information model of a physical system, including associated infrastructure and personnel, such as an electrical power system. The preferred embodiment of the invention provides a single, comprehensive description of the equipment in a power system, including network topology, operational constraints and limits, telemetry and communication details.

The organization of information in the power system data model is derived from an object-oriented analysis of the power system. In the invention, physical pieces of equipment are represented as objects with attributes that can be verified (primary data) and relations, including connectivity, grouping, and location.

The user interface provided by the present invention is based on a windowing environment. Where possible, data input is a matter of selection from a set of recognizable elements contained within the system. In this way, entry error is significantly reduced.

The present invention also provides interfaces to existing application program databases. Import interfaces allow existing data to be captured. Export interfaces allow continuing support of base application programs by the

present invention. Accordingly, the present invention provides a single, easy to use source for all proprietary application program databases at a utility.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a data flow diagram of an information model in accordance with the present invention;

Fig. 2 is a block level hierarchical representation of a data structure in accordance with the present invention;

Fig. 3 is a block level representation of a first level database menu in accordance with the present invention;

Fig. 4 is a block level representation of a type hierarchy menu in accordance with the present invention;

Fig. 5 is a block level representation of a group hierarchy menu in accordance with the present invention; and

Fig. 6 is a block level representation of a find object operation in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is best understood by referring to the Drawings in connection with review of this Description.

Power System Data Model

The present invention provides a database that finds application, for example, in the electric utility industry to hold attribute and connectivity data for electrical power system equipment. The invention reduces duplication of data and, through import and export capability, provides a single point of maintenance for the operations, planning, engineering, information services, and other departments of the electric utility. This feature of the invention eliminates the need to maintain multiple application program databases within the utility by replacing the multiple databases with a single, comprehensive point of maintenance.

The power system data model of the present invention allows the utility to define and maintain connectivity information for electrical equipment. The present invention has an information flow, as shown in block diagram form in Fig. 1, that provides a central repository of information about the equipment which forms the electrical generation, transmission, and distribution network of the electric utility. This central repository is referred to in Fig. 1 as the power system data model 10.

The power system data model is implemented in a relational database. The power system data model provides a data transfer path 11 for information transfer, including attribute and connectivity information. This information is transferred to a process 14 which generates input files. These input files are in turn exchanged, as indicated by the information transfer path 27, with the proprietary application program databases 16 that are used by the various departments within the utility, *e.g.* design, analysis,

planning, operations, and real-time software applications, including supervisory control and data acquisition (SCADA), distribution automation (DA/DMS), Energy management systems (EMS), and dispatcher training simulators (DTS).

The invention replaces the need to maintain multiple proprietary application program databases with a single, comprehensive point of maintenance in the power system data model 10. The external database generator 14 (14a-14n) uses the power system data model 10 to create data exchange files which contain attribute data in an appropriate format to populate any of several proprietary databases 16 (16a-16n) for use by operations, engineering, or other applications.

For example, an electrical utility Energy Management System may integrate real-time and analysis applications from several different vendors, each vendor having a different proprietary database. In such system, the maintenance associated with electrical network modeling is performed by the present invention. The data exchange files are transferred from the power system data model (exported) to the host system for the target database.

A data transfer path 25 is provided which allows information from the various proprietary databases to be imported to the power system data model through a data port 26. The data port receives existence, attribute, and connectivity information from the proprietary database and provides this information along a data transfer path 27 to the power system data model.

An historical data storage system 12 is included in the preferred embodiment of the invention that is capable of

storing timed samples (*i.e.* minimum, maximum, and average values every thirty seconds), continuous records (*i.e.* alarm and event logs), and snapshots (*i.e.* current system state) for later analysis. Such samples are provided along a data transfer path 23, which transfers information that is captured by an historical data capture process 18. The historical data capture process is in turn part of a data transfer path 25, which provides information to the historical data capture process from the various application programs 16 (16a-16n). The historical data storage system uses the power system data model 10, as shown by the data transfer path 13, to analyze historical data within the context of the power system.

The database design is easily extensible such that the power system data model can be expanded to encompass an enterprise data model. Thus, connections may be provided to external databases for AM/FM, GIS, and corporate computer systems.

For example, in some embodiments, the invention may operate in conjunction with an AM/FM/GIS system 20, in which existence and connectivity (described further below) establish one data transfer path 19 to the power system data model, and in which attributes establish another data transfer path 21 with regard to the power system data model.

The invention may be operated in a client-server environment including data servers, transaction managers, client applications, and user interface servers. Thus, a data server may be used to serve data to all interested users (clients). For example, user clients who are located throughout the power system network, a resource manager for the databases, and a transaction manager for a distributed

database system may all be served by data servers. A key point of the present invention is that the server provides a single (logical) model of the power system. Thus, there is only one comprehensive and consistent model of the power system, but that model may be distributed and/or replicated for better access throughout the power system network.

The invention provides processes both for interactive maintenance 22, having an attribute data transfer path 17, and for decision support 24, having an attribute/connectivity data transfer path 15 and a past performance data transfer path 29.

The present invention is implemented in relational database technology. Thus, relational tools are applied to data maintenance where traditional proprietary databases usually offer a user very little help, that is, in the areas of SQL access, ad-hoc queries, report generation, network access, and decision support. The present invention may be implemented using known database programming techniques. See, for example, Object-Oriented Systems Analysis, Shlaer and Mellor, Yourdon Press (1988) for a discussion of relational database techniques that are applicable in implementing the present invention.

Objects

The present invention is based on extending relational database technology and object-oriented systems analysis to a power system model. In object-oriented systems analysis, abstractions are produced that correspond to sets of physical things. These things are referred to as objects. Each object has a set of attributes which describe the object's

characteristics (discussed more fully below). A specific occurrence of an object, in which the object's attributes are populated with data, is referred to as an instance. All instances within a set of instances have the same characteristics and are subject to and conform to the same rules of behavior. Referential attributes are used to maintain the relationships between different objects.

The information model of the present invention describes:

- objects
- attributes of those objects;
- relationships between objects; and
- behavior of the object.

An object is an abstraction of a set of real-world things, *i.e.* underlying physical equipment, etc., such that:

- all real-world things in the set (the instances) have the same characteristics; and
- all instances are subject to and conform to the same rules and behavior.

Objects can be tangible things, roles, events, interactions, and specifications. Examples include:

- Tangible things: transformers, switches, lines;
- Roles: operators, dispatchers;
- Events: incidents, alarms, trouble calls, plans, schedules;
- Interactions: connections, measurements, groupings, correlations; and
- Specifications: equipment models, validation lists.

Lists of objects may be generated using a grouping mechanism to view the contents of the user-defined interactions, as well as lists of all the groups to which any single object belongs. Lists can also be generated using ad-hoc queries with pattern matching of object names.

An object is named based on the following criteria: common names are preferred, the names should be 'strong' names, the names should have the same dimension and be precise, the names should be based on the object's essential nature, and the name may be content based.

One aspect of the present invention provides a power system data model which is derived using an object-oriented analysis of a power system. The model represents the physical types of equipment and their connectivity. The model contains rules that maintain referential and electrical integrity and which simulate the behavior of the power system.

The power system data model defines the existence of and assigns unique keys to equipment in the power system. Based on object-oriented systems analysis, the preferred embodiment of the power system data model describes four main types of equipment (described more fully below): conducting equipment, sensing equipment, computer equipment, and support equipment. Relationships between equipment items are modeled, as are groupings that may be imposed by utility specific conventions.

Types

Typing is used in the present invention to enhance the description of an object in the database. For equipment in

the power system, typing is used to define a classification scheme that identifies the exact type of equipment to a degree of resolution defined by the end user. The same technique is used to identify other types of objects in the invention.

In the invention, supertypes and subtypes are used to categorize objects that are usually classified in a hierarchy. Thus, subtypes and supertypes are used to capture similarities between classes of things in the real world, including attributes and behavior. Subtypes and supertypes are used initially to model separate objects and then to bubble up the common attributes. This procedure establishes a type hierarchy which is used as a framework for the power system data model. In establishing subtypes and supertypes a bottom up system analysis is employed. Thus, the starting point is each physical element in the system.

A subtype is a more specific description of a parent supertype. A subtype therefore contains all properties possessed by its supertype. Thus, the attributes of a subtype are a property of a supertype object. For example, if all the subtypes of Switch have attributes describing their most recent state and normal state (Open or Closed), these attributes can be assigned to the switch object. They are then 'inherited' by all the objects that are a subtype of Switch. Other attributes may be common across many types of objects (*e.g.* manufacturer; location). These attributes may be moved up into classification objects, such as Conducting Equipment.

The present invention provides for three kinds of types:

- system types;
- user application types; and
- user types.

System types are pre-defined and may not be modified because they are necessary and fundamental to the correct operation of the power system model. User application types are used by user-written applications to define well known or reserved types. User types are defined and modified as necessary to express the desired depth of classification.

The three kinds of types are best understood as graphically depicted as follows:

Key Value	Type
1k-10K	Systems
10k-20k	Users
.	
.	
900k-1000k	
1M-1.01M	User-defined
.	
.	
999.99M-1000M	

Each new type must be related to a previously defined type. This relationship forms a supertype-type hierarchy. The hierarchy supports an unlimited number of levels but each type has one and only one supertype.

For example, a particular type of switch, *e.g.* a minimum oil circuit breaker, would be 'typed' by application of the invention as follows:

1.	Object	All things are objects.
2.	Equipment	It is a piece of real equipment...
3.	Conducting Equipment	...that is a part of the power system.
4.	Switch	It is a switch and...
5.	Breaker	...it can break load and...
6.	CB	...it is a circuit breaker and...
7.	Oil CB	...it is an oil circuit breaker and...
8.	M-OCB	...it is a minimum oil circuit breaker.

The invention defines types (Object, Equipment, Conducting Equipment, and Switch, above) that are used to allow the power system data model to interpret the type of object that is modeled. The user defined types (Breaker, CB, Oil CB, and Minimum-Oil CB, above) allow interactive users and user written applications to alter model behavior based on the type.

These types are depicted graphically as a hierarchy of types where the lower levels are subtypes. The four main types of equipment – conducting equipment, sensing equipment, computer equipment, and support equipment (discussed below) – are supertypes of the other equipment types, which may, in turn, be supertypes of still other types.

One unique aspect of the present invention also provides for basetypes (or fundamental types), *i.e.* a formalized point in the type hierarchy that encompasses a number of

similar subtypes (similar in attributes and behavior). The preferred embodiment of the present invention provides Breaker, Fuse, and Disconnect as base types, for example. All are subtypes of Switch (which could also be a basetype). Base types are used to map objects for editors, database tasks, and for procedures that model behavior. For example:

- Switch
  - Breaker (capable of interrupting load and reclosing)
    > OCB, M-OCB, VCB, ABCB, GCB
  - Fuse (capable of interrupting load)
    > Current limiting, power, cutout, vacuum
  - Disconnect (not capable of interrupting load)
    > Station, transmission, distribution

Attributes

Once the components of a power system and the arrangement of these components is set forth in terms of object-oriented analysis, the objects are assigned attributes. An attribute is the abstraction of a single characteristic possessed by all the things that were abstracted as objects. In the invention, it is preferred that attributes be collected for each of the objects identified. During this process, some of the attributes assigned to a group of objects are shared in common.

The invention provides for obtaining a set of attributes for objects, where the attributes are:

- complete: they capture all the information pertinent to the

object they define;
- fully factored: each attribute captures a separate aspect of the object abstraction; and
- mutually independent: the attributes take on their values independently of one another.

Attributes are assigned to four different categories depending on the type of information they capture:

· descriptive: intrinsic characteristics of an object, which are further divided into two categories, *i.e.*:
- primary: usually physically verifiable by observation, *e.g.* line length, tower type, conductor type; and
- secondary: not usually physically verifiable, but rather derived from others in the database by calculations that model behavior, *e.g.* impedance and capacitance;
· naming: arbitrary names and labels, *e.g.* line name;
· referential: facts that relate an instance of an object to an instance of another object, *e.g.* manufacturer, location (implemented using surrogate keys, discussed below); and
· identifiers: a set of one or more attributes that can uniquely identify an instance of an object, *e.g.* line name, segment name.

Attributes that can be derived from the primary data may be calculated automatically. For example, the primary data for a transformer is entered directly from the nameplate or test report. Individual winding characteristics are derived from this information. Transmission line impedances and admittances are derived from the primary data of conductor characteristics, tower geometry, and line segment lengths. Derived data may be input in lieu of primary data, if desired.

One unique aspect of the present invention is the use of two types of descriptive attributes. Thus, one goal of the present invention is to calculate secondary attributes where possible. Otherwise, direct entry of the attribute is employed. In this way, the present invention allows the modeling of system behavior.

Groups

Objects may be related to each other by assigning them to groups. Any particular object may belong to any unlimited number of different groups, although each object has a single primary group. Groupings are arbitrary collections of objects. Groups have meaning only as specified by the user. The objects in a group are related because they are member of (belong to) the same group. Groupings are modeled as relationships that may be imposed by utility specific conventions.

Relationships are abstractions of a set of associations that hold systematically between different kinds of things in the real world. There are an infinite number of relationships between types of things in a power system (and a large number of things themselves). Prior art approaches to modeling power systems express each relationship individually, resulting in unwieldy database structures. In the present invention, relationships may be:

- one-to-one;
- one-to-many; and
- many-to-many.

For example:

- a substation contains equipment;
- telemetry monitors equipment;
- lines are composed of segments;
- equipment may have a location;
- electrical equipment is connected to electrical equipment;
- electrical equipment may have ratings;
- transformers have windings.

Additionally, relationships may be conditional or unconditional.

One unique feature of the present invention provides for the use of one table for all groupings (*i.e.* for all relationships, such as 'member of,' 'located with,' and 'shown on'). Typically, a database of the type described herein would rely on a separate table for each grouping relationship between each type of object.

Group-Member Relationship

The present invention contains a description of group-member relationship. Both the group and the member are objects in the database. Where a division belongs to a company, the group is an object of the type *COMPANY*, the member is an object of type *DIVISION*, and the relationship is *BELONGS TO*. Other relationships may include: *LOCATED WITH*, which can be used to locate switches on poles that have a known address; *SHOWN ON*, which relates objects to maps and drawings; *RATED AS*, which allows a common set of ratings to be held for a set of similar equipment; and *LOAD MODELED BY*, which allows a common load model to be applied to similar consumers.

The *SYSTEM* grouping holds references to all the objects that make up a version of the power system data model. Generational versions record the evolution of the equipment in the power system. Between two versions, the grouping mechanism duplicates only the references to objects common to both, not the objects themselves.

Additionally, objects may be stored as members of groups in at least two ways:

- as an object: *e.g.* a transformer
- as a network position identifier: *e.g.* a position or place holder in the power system.

By assigning a dual nature to an object, the object itself may exist in the model, along with its attributes, and a place in the power system may be held into which objects having different attributes may be placed based on historical need. For example, a power system may have a network position identifier for a transformer. An object, *i.e.* a transformer having a particular rating, manufacturer, etc. may currently occupy that network position. Based on historical data, projected needs, etc., it may be determined that the network position occupied by the particular transformer should be occupied by a transformer having a different rating, etc. In this way, the power system data model (and, accordingly, the power system) is readily modified by equipment interchange based on demand, need, plan, etc. The historical data can also be applied to the object itself, allowing the history of a device to be analyzed.

Normalization Rules

The following normalization rules are provided by the invention which are applied to the attributes to ensure that the descriptions are coherent:

- One instance of an object has exactly one value for each attribute;
- Attributes cannot contain an internal structure; and
- Every non-key attribute must be fully dependent on the primary key.

The normalization rules are similar to those normally applied to the design of a relational database. The first rule defines a 'table' in the relational database.

The second rule ensures that the attributes are fully factored. This is essential to avoid 'hard-coded' knowledge of the meaning of parts of an attribute (*e.g.* the first two digits of the equipment number represent the year of purchase).

The third rule refers to the use of 'keys.' In a database there must be a way of uniquely identifying anything in the database. In a hierarchical database this is accomplished by the combination of the name of the item plus the names of the parents of the item (*e.g.* Substation Foo, Transformer T1). In a relational database, each row in a table must have a key of its own. In some applications this is simple (*e.g.* the name of a substation — Foo); in others compound (*e.g.* a name constructed from the identifier plus those of its parents — Foo T1).

The fourth rule requires that every attribute that is not part of the identifier must represent a characteristic of the entire object, and not a characteristic of something that is identified by part of the identifier (*e.g.* the attributes of the transformer Foo T1 cannot include the location of the substation Foo). This rule also prevents the use of attributes that are identified by other attributes within the object (*e.g.* the transformer may have a manufacturer attribute, but it is incorrect to store the manufacturer's address as an attribute of the transformer).

Surrogate Keys

In the preferred embodiment of the present invention, the actual primary key is modeled as a surrogate key, which is a computer generated numeric key that has no meaning to users. A surrogate key allows the user to change the name of an incidence of an object but not change references. All referential attributes are based on surrogate keys. Other (secondary) keys can be used to access objects by name, and the uniqueness rules for these keys can be defined on a case-by-case basis.

One unique feature of the present invention provides for the use of a balanced binary tree index with sequential keys. Surprisingly, the use of this technique in the present invention, taking advantage of the fact that the database is primarily 'read,' results in a much faster cycle time. Thus, the database is speeded up using a technique that would, by conventional wisdom, slow a database down.

Data Model

In summary, one aspect of the present invention provides a data model constructed in accordance with the following procedure:

· Create an extensible type hierarchy, allowing a user to extend types down the hierarchy;

· Collapse objects into tables, where attributes specific to all objects below base types are collapsed into type tables, and all objects above base types are collapsed into object tables:

- Use typing to identify an object (not a table name); and

- Use common object table with surrogate keys; and

· Externalize and collapse relationships, where three main relationships are defined in the preferred embodiment of the present invention, *i.e.* connectivity, measurements, and groupings:

- Use typing to identify the type and relationship.

The data model incorporates the following procedures and operations to ensure integrity:

· Referential: to enforce constraints imposed by the database design, *e.g.* relationships between tables;

· Validation: to evaluate against real-world criteria, *e.g.* use engineering rules of thumb to reject bad data; and

· Behavioral: to model behavior of equipment, *e.g.* calculate

secondary/primary descriptive attributes, or split up load models.

These procedures are triggered when data is changed, *e.g.* SQL insert, update, delete statements, etc. The procedures cannot be bypassed by using a different user interface. This is vital for integrity and prevents the use of so-called 'back doors' to corrupt the database. These procedures may be turned off, *e.g.* for maintenance.

Triggers make the presence of various procedures transparent. Thus, a user would not be aware of the operation of the database. Rather, values are entered and results displayed. This is discussed in greater detail below.

Physical Model

An important aspect of the present invention is the use of a physical model. Thus, the descriptive attributes recorded for an object are verifiable. For example, control center applications may require the impedances for a three-winding transformer to be specified on a per-winding basis, corrected for the system base MVA and kV levels. These impedances cannot be validated by inspection. In the prior art, it is common practice to enter these values directly into the databases used by the specific application programs concerned. If the data from the manufacturer's test report are entered into the database of the present invention, then the application data can be calculated at any point in the system. This test data has a known provenance which can be checked if a question arises about the validity of the data.

Another example of the foregoing involves transmission line

impedances. If the characteristics of conductor types and tower geometries are known, it is possible to calculate the positive sequence impedances from the primary data of the line length and construction. By adding more information about the ground resistivity and the relationships to other lines in the same right-of-way, zero sequence impedance can also be calculated.

The power system data model describes four main types of equipment: conducting equipment, sensing equipment, computer equipment, and support equipment. The following relationships are established between these four major types:

1. Sensing equipment -> measures -> conducting equipment;

2. Support equipment -> supports -> conducting equipment;

3. Conducting equipment -> is connected to -> conducting equipment; and

4. Computer equipment -> controls and models -> conducting equipment.

The main types of the conducting equipment are:

Conducting equipment -> capacitor, switch, transformer, generator, conductor, reactor, consumer, etc.

The sensing equipment is assigned two major subtypes:

Sensing equipment ->

- protection: voltage relay, current relay, frequency relay, etc.; and

- telemetry: analog, digital, counter, control, etc.

The support equipment encompasses the equipment needed to keep the network in place:

Support equipment ->
- overhead: tower, pad, pole, etc;
- underground: manhole, pit, vault, etc; and
- etc.

Computer equipment may be described as follows:

Computer equipment ->
- hardware: display, printer, etc;
- software: program.

The relationships in the power system data model may be extended by the end user. Groupings are used to aggregate the equipment into larger units that reflect the utility's organization. For example, a utility may choose to define groups of equipment as follows:

Equipment group -> system, company, division, substation, bay, line, circuit, etc.

A circuit breaker can belong to a bay that belongs to a substation that belongs to a division that belongs to a company. This is represented graphically as follows:

Company -> division -> substation -> bay -> circuit breaker.

The same circuit breaker may also belong to a transmission line which may belong to two different divisions of different

companies.

That is,

Company 1 -> division 1 ->
Company 2 -> division 2 ->
-> transmission line -> circuit breaker

These example groupings are specific to a particular utility. Each database user can choose different groupings to accurately reflect the utility's organization.

Fig. 2 is a block level representation of an object 30 as may be used in the present invention as a database member based on physical equipment having both a location 32 and a rating 34. The following types of conducting equipment are modeled in the power system data model provided in a preferred embodiment of the invention:

AC Overhead Line: The AC overhead line model constructs a line from a number of two terminal conductors 46. Each conductor has impedance and capacitance information associated with it that can either be entered directly or calculated by the power system data model from supplied primary data, *e.g.* tower geometry 43, conductor characteristics 41, and conductor length.

Busbar: Busbars 45 are considered subtypes of conductors 46 and may be modeled as physical devices, if desired. This characterization is in contrast to prior art practice of modeling a bus bar as an abstraction referred to as a node.

Capacitor: For capacitors 36, the installed MVAr is modeled.

Consumer: A consumer 38 is used to model a 'load' 33 on the power system. For a transmission model, consumers may be distribution feeders or major customers. If power system modeling is extended to include the distribution primary, consumers may be commercial enterprises with a high voltage supply or they may be housing developments. If desired, the model may be extended to individual meters. Each consumer has a base load expressed in MW or MVAr, plus voltage and frequency variations for the base load. A family of load curves that describe temporal variation of the base load can be associated with the consumer, such as season 35, day type 37, and load value 39.

Generator: Generator 42 MVA, MW, MVAr, and kV ratings, resistance and reactance, and parameters for the rate of change of the unit are modeled.

Reactor: For reactors 44, the installed MVAr is modeled.

Switch: The normal state of a switch 48 is modeled.

Transformer: The power system data model includes one- and three-phase, two- and three-winding transformers 50. Characteristics of the transformers may be entered directly from the nameplate and manufacturer's test reports as primary data, in which case the per-winding impedance information is calculated 49. The per-winding impedance data may be entered directly, if desired. Additionally, tap setting information 47 is modeled.

Transformer banks may also be supported by the present invention.

Additionally, the power system data model may also model PERSONs 54, COMPUTERs 56, and TELEMETRY 58, as desired.

User Interface

In the preferred embodiment of the invention, all equipment attribute data are maintained in a single database using a window-based graphical user interface. Primary data for an object are input directly by a user. The use of windowing in the user interface permits precise control of input data at the point of entry using pull down menus and slider bars having a range bounded by the physical limits of the modeled equipment. Thus, out of range or incorrect settings are not possible and a user can be guided through an interactive data input process with little previous experience or training.

Typically, the user of the invention is an engineer having responsibility for modeling decisions concerning the electrical power system. The user interface also allows efficient data entry for administrative personnel.

Thus, the present invention features a consistent graphical user interface across all applications and for all users. A user enters attribute data via pop-up menus, pull-down menus, scrollable lists, enterable fields, dialog boxes, and mouse pointing device support, generic implementation of which is well known in the art. Data entry fields are color coded to prompt the user for the appropriate type of input. For example, electrical connectivity is defined using point and click operations to reference the physical terminals of the equipment being connected.

The invention allows several editors to be active at the same time. An editor can be started for any object in the database by clicking at any reference to that object. In the equipment editor windows, the user selects from option lists that only offer valid choices. Existing equipment may be used as a template to simplify data entry for new equipment.

The user interface of the present invention is configurable in the preferred embodiment for OSF/MOTIF, Open Look, or Windows. Typical hardware support for the present invention may include workstation type computers, such as VAXstations running VAX/VMS with INGRES or DECstations running ULTRIX/RISC with INGRES, as supplied by Digital Equipment Corporation of Maynard, MA.

Operation

Fig. 3 shows a first level database menu 100 for a specific power system 110. At this level, a user accesses type hierarchy 120, system parameters 130, grouping selection 140, and object lists 150.

A user makes a selection in menu 100, for example type hierarchy 120, and is directed to a type menu 200 for the desired type hierarchy 210. Type hierarchy includes a name field 230 which identifies an established hierarchy for a specified object 240, which is further defined as equipment 250 (subtype) of a type that is conducting 260 (sub-subtype). Additional hierarchy may be provided in the remaining field 270 and several other fields, as desired, beneath it.

Once type and type hierarchy are established, a type selection is made 280, as specifically defined by a name

field 290. The selection is made from the available types 300-350, for example, ground, generator, consumer, capacitor, reactor, or switch; and any additional subtypes 360.

A grouping selection menu 400 for a specified grouping 410 is shown in Fig. 5. A first level in the menu displays group hierarchy 420 by type 430 and by name 440. Thus, group hierarchy may be structured as an organization 431 named ORGANIZATION 441, having a system 432 named SYS 442, in which there is a company 433 named CO 443, having a division 434 named DIV 444, containing a substation 435 named SUB 445, and so on.

For the group hierarchy, a group selection 450 is made, including a type 460 having a name 470. The list of objects selected would represent equipment within substation SUB and would be selected by type from a scrollable list 461-469 in which each piece of equipment on the list has a corresponding name 471-479.

For each group selected, a user can also identify members of the group 480, equipment details 490, and network connections 495.

Objects within the system may be located from the find object menu 500 for a specific object 510, as shown in Fig. 6. Thus, an object type is selected 520 from a list of types 521-524, which may include switch, system, telemetry equipment, etc. The object selected is associated with a group 530 having a relationship 532, such as 'contains,' 'starts with,' 'ends with,' 'matches,' and having a name 534. A corresponding name 540 also has a defined relation 542, such as 'contains' for a name 544. A look-up button 546

also provided to obtain a list of objects that match the search criteria.

The objects found are reported by number 550 and, by group 560, type 570, and name 580, each of which includes a corresponding list of matching objects (561-566, 571-576, and 581-586, respectively). Navigation through the menu is enhanced by an apply button 590 and a cancel button 595.

Although the invention is described herein with reference to the preferred embodiment, one skilled in the art will readily appreciate that additional applications, other than those set forth herein, may be substituted therefor without departing from the spirit and scope of the present invention. For example, the invention may be readily applied to other large, complex systems, including establishing models for process control in manufacturing plants and other physical systems. Accordingly, the invention should only be limited by the claims included below.

The following appendix provides source and object code listings and screen printouts for software included in this invention. The listings include database scheme definition, object editors for the power system data manager editor, and general use frames for the power system data manager.

```
/*****************************************************************************

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*****************************************************************************
```

```
/*
 *      The following domains are used in this model:
 *
 *      AbsoluteDate                A date in full dd-mm-yyyy hh:mm:ss form
 *      Address                     Address of component in computer system
 *      Amps                        Current flow (+ve into bus, -ve out of bus
 *      Bits                        Count of bits
 *      Boolean                     0 = False = No | 1 = True = Yes
 *      Comment                     Free form text
 *      ContactName                 Textual name of a contact person
 *      Coordinate                  Measurement of position on a grid
 *      Count                       Measurement of quantity
 *      Degrees/Step                Degrees of phase shift per tap step
 *      Description                 Textual description
 *      Exponent                    Exponentiation amount
 *      ForeignKey                  Reference to a primary key
 *      Hertz                       Cycles per second
 *      Interpolation               Type of interpolation between data points
 *      IntervalTime                A time between two points (usually hhh:mm:ss
 *      kV                          Value representing kV
 *      KVLevel                     Voltage level in kV
 *      KeyName                     Textual name of a key
 *      KeyValue                    Current value of a key
 *      LocationLine                Text describing a location
 *      LockCombination             Combination for a lock
 *      LongLength                  Long unit of length (e.g. mile; kilometer)
 *      LongLength/ShortLength      Ratio of long length to short length
 *      MVA                         Megavoltamperes
 *      MVAR                        Megavoltamperes Reactive
 *      MW                          Megawatt
 *      MW/min                      Megawatt rate of change per minute
 *      MeasurementSource           Reference to document defining measurement
 *      Name                        Textual name
 *      ObjectName                  Textual name of an object
 *      Ohm-ShortLength             Resistivity in ohms per-unit short length
 *      Ohms/LongLength             Resistance in ohms per unit long length
 *      ParticipationFactor         Generating unit economic participation facto
 *      PerCent                     Normally 0 - 100 on a defined base
 *      PerUnit                     Normally 0 - 1 on a defined base
 *      PerUnitMW-Sec               MW - second inertia on a defined base
 *      PerUnitMW/Freq              MW variation with frequency on a defined bas
 *      PerUnitkV/MVAR              Voltage variation with reactive power
 *      PhaseID                     Phase identification (A|B|C|3)
 *      PhoneNumber                 Telephone number
 *      PrimaryKey                  Unique reference to a row
 *      Problem                     Identifier of a problem description
 *      RatingType                  Type of measurement being rated
 *      Reference                   Reference to association between two objects
 *      SensorValue                 Physical value measured by a sensor
 *      SequenceNumber              Incrementing number used to order rows
 *      SerialNumber                Textual serial number string
 *      Severity                    Problem severity (F|E|W|I)
 *      ShortLength                 Short unit of length (e.g. foot; meter)
 *      SourceIdentifier            Reference to data source in foreign database
 *      TapStep                     Transformer tap step position
 *      TelemetryValue              Value of reading in telemetry system
 *      Temperature                 Value of temperature in TemperatureUnits
 *      TemperatureUnits            C | F
 *      Terminal                    Object terminal number
 *      TerminalCount               Maximum number of terminals for an object
 *      TypeName                    Textual name for an object type
 *      UserName                    Textual name for a user
 *      VersionNumber               Object version number
 *      WindingName                 Textual name for a transformer winding
 */
```

```
/*
 *      Object table. There is an entry in this table for every
 *      Equipment, Organisation and Specification entry.
 */
CREATE TABLE Object
(    Object                INTEGER      NOT NULL                  /* PrimaryKey */
,    Source                INTEGER      WITH NULL                 /* SourceIdentifier
,    SystemVersion         INTEGER      NOT NULL WITH DEFAULT     /* ForeignKey */
,    BaseType              INTEGER      NOT NULL WITH DEFAULT     /* ForeignKey */
,    Type                  INTEGER      NOT NULL WITH DEFAULT     /* ForeignKey */
,    PrimaryGrouping       INTEGER      NOT NULL WITH DEFAULT     /* ForeignKey */
,    TypeName              VARCHAR(20)  NOT NULL WITH DEFAULT     /* TypeName */
,    PrimaryGroupingName   VARCHAR(20)  NOT NULL WITH DEFAULT     /* ObjectName */
,    Name                  VARCHAR(20)  NOT NULL WITH DEFAULT     /* ObjectName */
,    Description           VARCHAR(60)  NOT NULL WITH DEFAULT     /* Description */
,    Comment               VARCHAR(200) NOT NULL WITH DEFAULT     /* Comment */
,    Terminals             INTEGER      NOT NULL WITH DEFAULT     /* TerminalCount
,    InService             DATE         WITH NULL                 /* AbsoluteDate */
,    OutService            DATE         WITH NULL                 /* AbsoluteDate */
,    PositionX             REAL         WITH NULL                 /* Coordinate */
,    PositionY             REAL         WITH NULL                 /* Coordinate */
,    OwnerNumber           CHAR(20)     NOT NULL WITH DEFAULT     /* SerialNumber */
,    SerialNumber          CHAR(20)     NOT NULL WITH DEFAULT     /* SerialNumber */
,    SpecNumber            CHAR(20)     NOT NULL WITH DEFAULT     /* SerialNumber */
,    Created               DATE         WITH NULL                 /* AbsoluteDate */
,    CreatedBy             CHAR(24)     NOT NULL WITH DEFAULT     /* UserName */
,    LastChanged           DATE         WITH NULL                 /* AbsoluteDate */
,    LastChangedBy         CHAR(24)     NOT NULL WITH DEFAULT     /* UserName */
);
```

```
/*
 *      Conducting equipment.
 *      Each type of conducting equipment has a table containing
 *      specific details pertaining to that type of equipment alone.
 */
CREATE TABLE Capacitor
(    Object                INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    NominalMVAR           REAL        WITH NULL               /* MVAR */
,    VoltSensitivity       REAL        WITH NULL               /* PerUnit kV/MVAR */
,    AVRDelay              DATE        WITH NULL               /* IntervalTime */
);
/*
 *      Transmission lines are made up of two-terminal segments, as
 *      are jumpers. Busbars have single terminals.
 */
CREATE TABLE Conductor
(    Object                INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    R                     REAL        WITH NULL               /* PerUnit */
,    X                     REAL        WITH NULL               /* PerUnit */
,    Bch                   REAL        WITH NULL               /* PerUnit */
,    Length                REAL        WITH NULL               /* LongLength */
,    TowerType             INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    GroundConductorType   INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    PhaseConductorType    INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    PhaseConductorCount   INTEGER     NOT NULL WITH DEFAULT   /* Count */
,    PhaseConductorSpacing REAL        NOT NULL WITH DEFAULT   /* ShortLength */
);
/*
 *      Consumers (loads) are modeled as a fixed part and a variable part.
 *      The fixed part represents an unchanging portion of the load
 *      (e.g. station load). The variable part is represents the rest of
 *      the load. It is made up of a nominal load, plus voltage and frequency
 *      variations (Dommel eq. 94). This portion of the load is also subject
 *      to time variations defined by the load curve associated with the
 *      consumer. The percentage of the total load in the uppermost load
 *      area for which this consumer is a member is also stored, together
 *      with a reference to this uppermost load area. (Note that load areas
 *      are also modeled as consumers).
 */
CREATE TABLE Consumer
(    Object                INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    Type                  INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    TopLoadArea           INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    Pfixed                REAL        WITH NULL               /* MW */
,    Qfixed                REAL        WITH NULL               /* MVAR */
,    Pnom                  REAL        WITH NULL               /* MW */
,    Qnom                  REAL        WITH NULL               /* MVAR */
,    PowerFactor           REAL        WITH NULL               /* Cosine */
,    PfixedPct             REAL        WITH NULL               /* Percent */
,    QfixedPct             REAL        WITH NULL               /* Percent */
,    PnomPct               REAL        WITH NULL               /* Percent */
,    QnomPct               REAL        WITH NULL               /* Percent */
,    PVexp                 REAL        WITH NULL               /* Exponent */
,    QVexp                 REAL        WITH NULL               /* Exponent */
,    PFexp                 REAL        WITH NULL               /* Exponent */
,    QFexp                 REAL        WITH NULL               /* Exponent */
);
```

```
CREATE TABLE Generator
(    Object                INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    RatedMVA              REAL        WITH NULL               /* MVA */
,    MinimumMW             REAL        WITH NULL               /* MW */
,    BaseMW                REAL        WITH NULL               /* MW */
,    MaximumMW             REAL        WITH NULL               /* MW */
,    MinimumMVAR           REAL        WITH NULL               /* MVAR */
,    BaseMVAR              REAL        WITH NULL               /* MVAR */
,    MaximumMVAR           REAL        WITH NULL               /* MVAR */
,    MinimumKV             REAL        WITH NULL               /* kV */
,    MaximumKV             REAL        WITH NULL               /* kV */
,    X                     REAL        WITH NULL               /* PerUnit */
,    R                     REAL        WITH NULL               /* PerUnit */
,    Inertia               REAL        WITH NULL               /* PerUnit MW-Sec *
,    Damping               REAL        WITH NULL               /* PerUnit MW/Freq *
,    ManualToAVR           DATE        WITH NULL               /* IntervalTime */
,    AVRToManualLag        DATE        WITH NULL               /* IntervalTime */
,    AVRToManualLead       DATE        WITH NULL               /* IntervalTime */
,    NormalPF              REAL        WITH NULL               /* ParticipationFact
,    ShortPF               REAL        WITH NULL               /* ParticipationFact
,    LongPF                REAL        WITH NULL               /* ParticipationFact
,    DownRampRate          REAL        WITH NULL               /* MW/min */
,    UpRampRate            REAL        WITH NULL               /* MW/min */
);
CREATE TABLE Reactor
(    Object                INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    NominalMVAR           REAL        WITH NULL               /* MVAR */
,    VoltSensitivity       REAL        WITH NULL               /* PerUnit kV/MVAR *
,    AVRDelay              DATE        WITH NULL               /* IntervalTime */
);
CREATE TABLE Switch
(    Object                INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,    NormalOpen            INTEGER     NOT NULL WITH DEFAULT   /* Boolean */
,    CurrentlyOpen         INTEGER     NOT NULL WITH DEFAULT   /* Boolean */
,    RelayType             INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
);
```

```
/*
 *      The transformer table contains information relating to the transformer a
 *      a whole. These are mostly related to the magnetizing branch characteris
 *      which are dependent on the core of the transformer.
 */
CREATE TABLE Transformer
(    Object                INTEGER      NOT NULL WITH DEFAULT    /* ForeignKey */
,    Bank                  INTEGER      NOT NULL WITH DEFAULT    /* ForeignKey */
,    Phases                CHAR(1)      NOT NULL WITH DEFAULT    /* PhaseID */
,    MagBaseKV             REAL         WITH NULL                /* kV */
,    Gmag                  REAL         WITH NULL                /* PerUnit */
,    Bmag                  REAL         WITH NULL                /* PerUnit */
,    MagSatFlux            REAL         WITH NULL                /* PerUnit */
,    BmagSat               REAL         WITH NULL                /* PerUnit */
);
/*
 *    Each transformer is made up of a number of windings
 */
CREATE TABLE Winding
(    Object                INTEGER      NOT NULL WITH DEFAULT    /* ForeignKey */
,    Winding               INTEGER      NOT NULL WITH DEFAULT    /* SequenceNumber
,    Source                INTEGER      NOT NULL WITH DEFAULT    /* SourceIdentifier
,    Name                  CHAR(10)     NOT NULL WITH DEFAULT    /* WindingName */
,    LoadTapChanger        INTEGER      NOT NULL WITH DEFAULT    /* Boolean */
,    NominalKV             REAL         NOT NULL                 /* KVLevel */
,    NeutralKV             REAL         NOT NULL WITH DEFAULT    /* kV */
,    BIL                   REAL         WITH NULL                /* kV */
,    RatedMVA              REAL         WITH NULL                /* MVA */
,    ShortTermMVA          REAL         WITH NULL                /* MVA */
,    EmergencyMVA          REAL         WITH NULL                /* MVA */
,    LowStep               INTEGER      NOT NULL WITH DEFAULT    /* TapStep */
,    HighStep              INTEGER      NOT NULL WITH DEFAULT    /* TapStep */
,    NeutralStep           INTEGER      NOT NULL WITH DEFAULT    /* TapStep */
,    StepSize              REAL         WITH NULL                /* PerCent */
,    PhaseShift            REAL         WITH NULL                /* Degrees/Step */
);
```

```
/*
 *      Each transformer may have a number of measurements done at different
 *      tap settings. These can have two sources: the primary source is the
 *      manufacturers test report, which contains impedance information in perce
 *      measured at one winding with a reference winding shorted. The secondary
 *      source are the impedances derived from this test report. These are
 *      specified on a per-winding basis, corrected for system base MVA and
 *      system base kV. These are needed by analytical applications, and are eit
 *      derived from tthe primary, or loaded directly if the primary information
 *      is not available.
 */
CREATE TABLE TapSetting
(    Object              INTEGER      NOT NULL WITH DEFAULT    /* ForeignKey */
,    Winding1            INTEGER      NOT NULL WITH DEFAULT    /* SequenceNumber *
,    TapStep1            INTEGER      NOT NULL WITH DEFAULT    /* TapStep */
,    Winding2            INTEGER      NOT NULL WITH DEFAULT    /* SequenceNumber *
,    TapStep2            INTEGER      NOT NULL WITH DEFAULT    /* TapStep */
,    Winding3            INTEGER      NOT NULL WITH DEFAULT    /* SequenceNumber *
,    TapStep3            INTEGER      NOT NULL WITH DEFAULT    /* TapStep */
,    Source              CHAR(20)     NOT NULL WITH DEFAULT    /* MeasurementSource
,    R0_1_2              REAL         WITH NULL                /* PerCent */
,    Z0_1_2              REAL         WITH NULL                /* PerCent */
,    R1_1_2              REAL         WITH NULL                /* PerCent */
,    Z1_1_2              REAL         WITH NULL                /* PerCent */
,    R0_2_3              REAL         WITH NULL                /* PerCent */
,    Z0_2_3              REAL         WITH NULL                /* PerCent */
,    R1_2_3              REAL         WITH NULL                /* PerCent */
,    Z1_2_3              REAL         WITH NULL                /* PerCent */
,    R0_3_1              REAL         WITH NULL                /* PerCent */
,    Z0_3_1              REAL         WITH NULL                /* PerCent */
,    R1_3_1              REAL         WITH NULL                /* PerCent */
,    Z1_3_1              REAL         WITH NULL                /* PerCent */
,    R0_1                REAL         WITH NULL                /* PerCent */
,    Z0_1                REAL         WITH NULL                /* PerCent */
,    X0_1                REAL         WITH NULL                /* PerCent */
,    R1_1                REAL         WITH NULL                /* PerCent */
,    Z1_1                REAL         WITH NULL                /* PerCent */
,    X1_1                REAL         WITH NULL                /* PerCent */
,    R0_2                REAL         WITH NULL                /* PerCent */
,    Z0_2                REAL         WITH NULL                /* PerCent */
,    X0_2                REAL         WITH NULL                /* PerCent */
,    R1_2                REAL         WITH NULL                /* PerCent */
,    Z1_2                REAL         WITH NULL                /* PerCent */
,    X1_2                REAL         WITH NULL                /* PerCent */
,    R0_3                REAL         WITH NULL                /* PerCent */
,    Z0_3                REAL         WITH NULL                /* PerCent */
,    X0_3                REAL         WITH NULL                /* PerCent */
,    R1_3                REAL         WITH NULL                /* PerCent */
,    Z1_3                REAL         WITH NULL                /* PerCent */
,    X1_3                REAL         WITH NULL                /* PerCent */
);
```

```
/*
 *      Sensing Equipment.
 */
CREATE TABLE Telemetry
(    Object                 INTEGER      NOT NULL WITH DEFAULT    /* ForeignKey */
,    TelemetryMinimum       INTEGER      NOT NULL WITH DEFAULT    /* TelemetryValue *
,    TelemetryMaximum       INTEGER      NOT NULL WITH DEFAULT    /* TelemetryValue *
,    XORMask                INTEGER      NOT NULL WITH DEFAULT    /* TelemetryValue *
,    Input                  INTEGER      NOT NULL WITH DEFAULT    /* Boolean */
,    Output                 INTEGER      NOT NULL WITH DEFAULT    /* Boolean */
,    CardAddress            INTEGER      NOT NULL WITH DEFAULT    /* Address */
,    WordAddress            INTEGER      NOT NULL WITH DEFAULT    /* Address */
,    Size                   INTEGER      NOT NULL WITH DEFAULT    /* Bits */
,    Offset                 INTEGER      NOT NULL WITH DEFAULT    /* Bits */
,    PowerCable             CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
,    ReturnCable            CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
,    GroundCable            CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
,    TerminationCable       CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
,    Panel                  CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
);
/*
 *      Computer Equipment.
 */
CREATE TABLE Computer
(    Object                 INTEGER      NOT NULL WITH DEFAULT    /* ForeignKey */
,    ObjectAddress          INTEGER      NOT NULL WITH DEFAULT    /* Address */
,    Controller             CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
,    ControllerAddress      INTEGER      NOT NULL WITH DEFAULT    /* Address */
,    Cable                  CHAR(20)     NOT NULL WITH DEFAULT    /* Name */
);
```

```
/*
 *      Specification objects
 */
/*
 *      Conductor details from the manufacturer. Characteristic of the conductor
 *      as supplied by the manufacturer are tabulated.
 */
CREATE TABLE ConductorType
(   Object              INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,   Resistance          REAL        NOT NULL WITH DEFAULT   /* Ohms/LongLength *
,   Radius              REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   GMR                 REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   Ampacity            REAL        NOT NULL WITH DEFAULT   /* Amps */
);
/*
 *      Tower geometry is tabulated for a three phase, single or double circuit,
 *      with 0, 1, or 2 ground wires. Offsets from an arbitrary datum, and
 *      the height above ground are used.
 */
CREATE TABLE TowerType
(   Object              INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,   A1_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   A1_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   B1_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   B1_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   C1_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   C1_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   G1_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   G1_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   A2_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   A2_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   B2_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   B2_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   C2_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   C2_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   G2_Offset           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
,   G2_Height           REAL        NOT NULL WITH DEFAULT   /* ShortLength */
);
/*
 *      The Person table holds specific attributes for people who need
 *      to be known to the system.
 */
CREATE TABLE Person
(   Object              INTEGER     NOT NULL WITH DEFAULT   /* ForeignKey */
,   LoginName           CHAR(20)    NOT NULL WITH DEFAULT   /* Name */
,   Password            CHAR(20)    NOT NULL WITH DEFAULT   /* Name */
,   Initials            CHAR(4)     NOT NULL WITH DEFAULT   /* Initials */
);
```

```
/*
 *      Object typing
 */
/*
 *      The LastKey table contains the last key value used for the different
 *      key types used in the system. Each key is an integer value that increme
 *      with each use. The key values start at 10000 for user-defined entities.
 *      System-defined entities are loaded on database initialization with key
 *      values that are less than 10000.
 */
CREATE TABLE LastKey
(   LastKey             CHAR(8)         NOT NULL            /* KeyName */
,   Value               INTEGER         NOT NULL            /* KeyValue */
);
/*
 *      List all problems and their descriptions
 */
CREATE TABLE Problem
(   Problem             CHAR(20)    NOT NULL                /* Problem */
,   Severity            CHAR(1)     NOT NULL WITH DEFAULT   /* Severity */
,   Description         CHAR(60)    NOT NULL WITH DEFAULT   /* Description */
);
/*
 *      Set up the base type table. This is used to set up base type
 *      editors and specific table names
 */
CREATE TABLE BaseType
(   Type                INTEGER     NOT NULL                /* ForeignKey */
,   EditorName          CHAR(20)    WITH NULL               /* Name */
,   TableName           CHAR(20)    WITH NULL               /* Name */
);
/*
 *      Set up the type validation table. This table is used to specify the
 *      valid type names.
 */
CREATE TABLE Type
(   Type                INTEGER     NOT NULL                /* PrimaryKey */
,   BaseType            INTEGER     NOT NULL                /* ForeignKey */
,   Name                CHAR(20)    NOT NULL                /* TypeName */
);
/*
 *      Table containing type - supertype relationships. This table is used to
 *      define the SuperType to SubType heirarchy.
 */
CREATE TABLE SuperType
(   Type                INTEGER     NOT NULL                /* ForeignKey */
,   SuperType           INTEGER     NOT NULL                /* ForeignKey */
);
/*
 *      Table containing extended type - supertype relationships. This table
 *      is a flattened version of the SuperType table. Each type is cataloged
 *      with all its SuperTypes.
 */
CREATE TABLE ExtendedType
(   Type                INTEGER     NOT NULL                /* ForeignKey */
,   SuperType           INTEGER     NOT NULL                /* ForeignKey */
);
```

```
/*
 *      Parameters relating to the system being modelled are defined here.
 *
 *      Frequency is the system base frequency (default 60)
 *      MVABase is the system MVA base for per-unit tranformations (default 1
 *      KVReference is the kV to use for per-unit transformations (default 1)
 *      LengthRatio is the ratio of the Longlength over the ShortLength
 *          Typical values are: 1000 for SI units (km / m) (default)
 *                              5280 for British-American units (mile / foot)
 *      GroundResistivity is used in zero sequence calculations (default 100 ohm
 */
CREATE TABLE SystemParameters
(   Frequency           REAL        NOT NULL                    /* Hertz */
,   MVABase             REAL        NOT NULL                    /* MVA */
,   KVReference         REAL        NOT NULL                    /* kV */
,   LengthRatio         REAL        NOT NULL                    /* LongLength/Short
,   GroundResistivity   REAL        NOT NULL                    /* Ohm-ShortLength
,   Temperature         CHAR(1)     NOT NULL                    /* TemperatureUnits
);
/*
 *      Validation table for system kV levels
 */
CREATE TABLE KVLevel
(   KVLevel             REAL        NOT NULL                    /* KVLevel */
,   Name                CHAR(20)    NOT NULL WITH DEFAULT       /* Name */
,   Voltage             REAL        NOT NULL                    /* KVLevel */
);
```

```
/*
 *      Locations of objects (e.g. address). This table is keyed by the object
 *      which defines the location (typically of type Support Equipment or
 *      Organization), but may be referenced by any object
 */
CREATE TABLE Location
(   Object              INTEGER      NOT NULL                    /* ForeignKey */
,   Combination         CHAR(4)      NOT NULL WITH DEFAULT       /* LockCombination */
,   Phone               VARCHAR(20)  NOT NULL WITH DEFAULT       /* PhoneNumber */
,   Contact             VARCHAR(40)  NOT NULL WITH DEFAULT       /* ContactName */
,   L1                  VARCHAR(80)  NOT NULL WITH DEFAULT       /* LocationLine */
,   L2                  VARCHAR(80)  NOT NULL WITH DEFAULT       /* LocationLine */
,   L3                  VARCHAR(80)  NOT NULL WITH DEFAULT       /* LocationLine */
,   L4                  VARCHAR(80)  NOT NULL WITH DEFAULT       /* LocationLine */
,   Comment             VARCHAR(200) NOT NULL WITH DEFAULT       /* Comment */
);
/*
 *      Set up the object rating table. Any object can have a set of ratings
 *      associated with it. The rating type defines the characteristic being
 *      rated (e.g. Amps, MVA, MW). Four values can be supplied: it is assumed
 *      that the ordering is Normal < ShortTerm < Emergency < Loadshed.
 */
CREATE TABLE Rating
(   Object              INTEGER      NOT NULL WITH DEFAULT       /* ForeignKey */
,   Type                CHAR(10)     NOT NULL WITH DEFAULT       /* RatingType */
,   Season              INTEGER      NOT NULL WITH DEFAULT       /* ForeignKey */
,   Temperature         REAL         WITH NULL                   /* Temperature */
,   Normal              REAL         WITH NULL
,   ShortTerm           REAL         WITH NULL
,   Emergency           REAL         WITH NULL
,   Loadshed            REAL         WITH NULL
);
/*
 *      LoadCurves are used to store the time variation of a load class with
 *      respect to a base value. Families of load curves can be constructed for
 *      different seasons and day types (e.g Summer Weekend; Winter Weekday).
 *      The values supplied for the curve are interpolated as directed. Load
 *      curves are constucted for an entire day (00:00:00 to 23:59:59), and
 *      can be put together by applications to generate a profile as required.
 */
CREATE TABLE LoadCurve
(   Object              INTEGER      WITH NULL                   /* ForeignKey */
,   DayType             INTEGER      NOT NULL WITH DEFAULT       /* ForeignKey */
,   Season              INTEGER      NOT NULL WITH DEFAULT       /* ForeignKey */
,   Temperature         REAL         WITH NULL                   /* Temperature */
,   LoadCurve           INTEGER      NOT NULL WITH DEFAULT       /* PrimaryKey */
,   Source              INTEGER      WITH NULL                   /* SourceIdentifier
,   Interpolate         CHAR(6)      NOT NULL WITH DEFAULT       /* Interpolation */
);
CREATE TABLE LoadValue
(   LoadCurve           INTEGER      NOT NULL WITH DEFAULT       /* PrimaryKey */
,   Time                DATE         NOT NULL WITH DEFAULT       /* IntervalTime */
,   LoadValue           REAL         NOT NULL WITH DEFAULT       /* PerUnit */
,   Source              INTEGER      WITH NULL                   /* SourceIdentifier
);
```

```
/*
 *      Interactions
 */
/*
 *      Equipment terminals. Each object can have a variable number of terminals
 *      which can be connected to other terminals. The node is used as a
 *      common reference between connected terminals.
 */
CREATE TABLE Terminal
(   Object              INTEGER     NOT NULL                    /* ForeignKey */
,   BaseType            INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Terminal            INTEGER     NOT NULL                    /* Terminal */
,   Node                INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   KVLevel             REAL        NOT NULL WITH DEFAULT       /* KVLevel */
);
/*
 *      Measurements made on the equipment. Each measurement measures
 *      something (the measurand) using an agent (the measurer).
 *
 *      The measurand has a type (e.g. kV, Status, MW, Amps) that defines
 *      the quantity being measured. It refers to the object being measured,
 *      and may be made at no terminal (e.g. fire alarm), at one terminal
 *      (e.g. voltage), or between two terminals (e.g. breaker status).
 *
 *      The measurand may be represented by a sensor. This has a type
 *      (e.g. current, voltage, frequency, position, impulse, contact) and
 *      a minimum and maximum that are expressed in the units of the
 *      measurand.
 *
 *      The measurer has a type (e.g. telemetered, manual, state estimated,
 *      calculated, from other system) that defines the point of entry of the
 *      measurement. It may refer to an object that is present at that point
 *      of entry (e.g. a telemetry input).
 */
CREATE TABLE Measurement
(   Measurand           INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   MeasurandType       INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Terminal1           INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Terminal2           INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   SensorType          INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   SensorMinimum       REAL        NOT NULL WITH DEFAULT       /* SensorValue */
,   SensorMaximum       REAL        NOT NULL WITH DEFAULT       /* SensorValue */
,   SensorAccuracy      REAL        NOT NULL WITH DEFAULT       /* PerCent */
,   ReversePolarity     INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
,   MeasurerType        INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Measurer            INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Alarm               INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
,   History             INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
,   Trigger             INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
,   EventLog            INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
,   Input               INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
,   Output              INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
);
/*
 *      Set up the grouping validation table. This contains the group - member
 *      relationships for objects.
 */
CREATE TABLE Grouping
(   SystemVersion       INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Grouping            INTEGER     NOT NULL                    /* ForeignKey */
,   GroupingType        INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Member              INTEGER     NOT NULL                    /* ForeignKey */
,   MemberType          INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Relationship        INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Reference           CHAR(10)    NOT NULL WITH DEFAULT       /* Reference */
```

```
/*
 *      Grass catcher table - somewhere to throw all the problems
 */
CREATE TABLE GrassCatcher
(   Object              INTEGER     NOT NULL                    /* ForeignKey */
,   Problem             CHAR(20)    NOT NULL                    /* ForeignKey */
,   Text                CHAR(20)    NOT NULL WITH DEFAULT       /* Text */
,   Known               INTEGER     NOT NULL WITH DEFAULT       /* Boolean */
);
/*
 *      Temporary tables used as workspace for procedures embedded in
 *      the database
 */
/*
 *      List of terminals connected to objects (identical to Terminal table)
 */
CREATE TABLE TEMP$TerminalList
(   Object              INTEGER     NOT NULL                    /* ForeignKey */
,   BaseType            INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   Terminal            INTEGER     NOT NULL                    /* Terminal */
,   Node                INTEGER     NOT NULL WITH DEFAULT       /* ForeignKey */
,   KVLevel             REAL        NOT NULL WITH DEFAULT       /* KVLevel */
);
/*
 *      List of object and their voltage levels.
 */
CREATE TABLE TEMP$ObjectList
(   Object              INTEGER     NOT NULL                    /* ForeignKey */
,   KVLevel             REAL        NOT NULL WITH DEFAULT       /* KVLevel */
);
/*
 *      Table to use as an audit trail of where we have been
 */
CREATE TABLE TEMP$AuditTrail
(   Object              INTEGER     NOT NULL                    /* ForeignKey */
);
```

```
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 *****************************************************************************/

MODIFY Object TO BTree UNIQUE
    ON Object;

MODIFY Capacitor TO BTree UNIQUE
    ON Object;

MODIFY Conductor TO BTree UNIQUE
    ON Object;

MODIFY Consumer TO BTree UNIQUE
    ON Object;

MODIFY Generator TO BTree UNIQUE
    ON Object;

MODIFY Reactor TO BTree UNIQUE
    ON Object;

MODIFY Switch TO BTree UNIQUE
    ON Object;

MODIFY Transformer TO BTree UNIQUE
    ON Object;

MODIFY Winding TO BTree UNIQUE
    On Object, Winding;

MODIFY TapSetting TO BTree UNIQUE
    On Object, Winding1, TapStep1, Winding2, TapStep2;

MODIFY Telemetry TO BTree UNIQUE
    ON Object;

MODIFY Computer TO BTree UNIQUE
    ON Object;

MODIFY ConductorType TO BTree UNIQUE
    ON Object;

MODIFY TowerType TO BTree UNIQUE
    ON Object;

MODIFY Person TO BTree UNIQUE
    ON Object;

MODIFY Problem TO BTree UNIQUE
    ON Problem;
```

```
MODIFY BaseType TO BTree UNIQUE
    ON Type;

MODIFY Type TO BTree UNIQUE
    ON Type, Name;

MODIFY SuperType TO BTree UNIQUE
    ON Type, SuperType;

MODIFY ExtendedType TO BTree UNIQUE
    ON Type, SuperType;

MODIFY KVLevel TO BTree UNIQUE
    ON KVLevel;

MODIFY Location TO BTree UNIQUE
    ON Object;

MODIFY Rating TO BTree UNIQUE
    ON Object, Type;

MODIFY LoadCurve TO BTree UNIQUE
    ON Object, DayType, Season, Temperature;

MODIFY LoadValue TO BTree UNIQUE
    ON LoadCurve, Time;

MODIFY Terminal TO BTree UNIQUE
    ON Object, Terminal, Node;

MODIFY Measurement TO Btree UNIQUE
    ON Measurand, MeasurandType, Terminal1, Terminal2;

MODIFY Grouping TO BTree UNIQUE
    ON Grouping, Relationship, Member;

MODIFY GrassCatcher TO BTree    /* Also done in GrassCatcher frame */
    ON Object, Problem;
```

```
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*****************************************************************************/

CREATE UNIQUE INDEX Object$1
    ON Object (Type, PrimaryGroupingName, Name)
    WITH STRUCTURE = BTREE;

CREATE UNIQUE INDEX Object$2
    ON Object (PrimaryGrouping, Object)
    WITH STRUCTURE = BTREE;

CREATE UNIQUE INDEX LoadCurve$1 ON LoadCurve
    (LoadCurve)
    WITH STRUCTURE = BTree;

CREATE UNIQUE INDEX ExtendedType$1
    ON ExtendedType (SuperType, Type)
    WITH STRUCTURE = BTREE;

CREATE UNIQUE INDEX Terminal$1 ON Terminal
    (Node, Object, Terminal)
    WITH STRUCTURE = BTree;

CREATE UNIQUE INDEX Grouping$1 ON Grouping
    (Member, Relationship, Grouping)
    WITH STRUCTURE = BTree;
```

```
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*****************************************************************************/

/*
 *      This file contain rules that fire in order to trigger external
 *      notification events to interested parties. The events themselves,
 *      plus a generic procedure to raise them, are also defined here.
 *
 *      The rules in this file are not required to be active. Therefore
 *      every rule that is defined in this file must have a corresponding
 *      entry in the file "drop_notification.sql", which can be
 *      executed to drop the rules when desired. A nawk program,
 *      create_to_drop.nawk exists for this purpose, and can be run
 *      with the command:
 *
 *      "nawk -f create_to_drop.nawk\
 *          create_notification.sql\
 *          > drop_notification.sql"
 */

/*
 *      Define the events that can be raised
 */

CREATE DBEVENT Udb_ChangeName;
CREATE DBEVENT Udb_ChangeObject;
CREATE DBEVENT Udb_ChangeElectrical;
CREATE DBEVENT Udb_ChangeConnectivity;

/*
 *      Handle changes to the object record
 */
CREATE PROCEDURE Udb_Change$Name
(   PrimaryGroupingName     VARCHAR(20) NOT NULL
,   TypeName                VARCHAR(20) NOT NULL
,   Name                    VARCHAR(20) NOT NULL
) =
    DECLARE
        EventText           VARCHAR(256) NOT NULL;
    BEGIN
        EventText = SQUEEZE (PrimaryGroupingName + ' ' + TypeName + ' ' + Name
        RAISE DBEVENT Udb_ChangeName :EventText;
    END;

CREATE RULE Udb_Change$Name
    AFTER INSERT, UPDATE ON Object
    WHERE   Old.PrimaryGroupingName != New.PrimaryGroupingName OR
            Old.TypeName != New.TypeName OR
            Old.Name != New.Name
    EXECUTE PROCEDURE Udb_Change$Name
```

```
    (   PrimaryGroupingName = New.PrimaryGroupingName
    ,   TypeName = New.TypeName
    ,   Name = New.Name
    );

CREATE PROCEDURE Udb_Change$Object
(   Tid                     INTEGER
) =
    DECLARE
        PrimaryGroupingName VARCHAR(20) NOT NULL;
        TypeName            VARCHAR(20) NOT NULL;
        Name                VARCHAR(20) NOT NULL;
        EventText           VARCHAR(256) NOT NULL;
    BEGIN
        SELECT  :PrimaryGroupingName = O.PrimaryGroupingName,
                :TypeName = O.TypeName,
                :Name = O.Name
        FROM    Object O
        WHERE   :Tid = O.Tid;
        EventText = SQUEEZE (PrimaryGroupingName + ' ' + TypeName + ' ' + Name);
        RAISE DBEVENT Udb_ChangeObject :EventText;
    END;

CREATE RULE Udb_Change$Object
    AFTER INSERT, UPDATE ON Object
    WHERE   Old.Description != New.Description OR
            Old.Comment != New.Comment OR
            Old.Terminals != New.Terminals OR
            Old.InService != New.InService OR
            Old.OutService != New.OutService OR
            Old.PositionX != New.PositionX OR
            Old.PositionY != New.PositionY OR
            Old.OwnerNumber != New.OwnerNumber OR
            Old.SerialNumber != New.SerialNumber OR
            Old.SpecNumber != New.SpecNumber
    EXECUTE PROCEDURE Udb_Change$Object
    (   Tid = New.Tid
    );
/*
 *      Conducting plant
 */
CREATE PROCEDURE Udb_Change$Electrical
(   Object                  INTEGER
) =
    DECLARE
        PrimaryGroupingName VARCHAR(20) NOT NULL;
        TypeName            VARCHAR(20) NOT NULL;
        Name                VARCHAR(20) NOT NULL;
        EventText           VARCHAR(256) NOT NULL;
    BEGIN
        SELECT  :PrimaryGroupingName = O.PrimaryGroupingName,
                :TypeName = O.TypeName,
                :Name = O.Name
        FROM    Object O
        WHERE   :Object = O.Object;
        EventText = SQUEEZE (PrimaryGroupingName + ' ' + TypeName + ' ' + Name);
        RAISE DBEVENT Udb_ChangeElectrical :EventText;
    END;

CREATE RULE Udb_Change$Capacitor
    AFTER INSERT, UPDATE ON Capacitor
    EXECUTE PROCEDURE Udb_Change$Electrical
    (   Object = New.Object
    );

CREATE RULE Udb_Change$Conductor
```

```
        AFTER INSERT, UPDATE ON Conductor
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$Consumer
        AFTER INSERT, UPDATE ON Consumer
        WHERE   Old.Pfixed != New.Pfixed OR
                Old.Qfixed != New.Qfixed OR
                Old.Pnom != New.Pnom OR
                Old.Qnom != New.Qnom OR
                Old.PVexp != New.PVexp OR
                Old.QVexp != New.QVexp OR
                Old.PFexp != New.PFexp OR
                Old.QFexp != New.QFexp
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$Generator
        AFTER INSERT, UPDATE ON Generator
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$Reactor
        AFTER INSERT, UPDATE ON Reactor
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$Switch
        AFTER INSERT, UPDATE ON Switch
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$Transformer
        AFTER INSERT, UPDATE ON Transformer
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$Winding
        AFTER INSERT, UPDATE ON Winding
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );

    CREATE RULE Udb_Change$TapSetting
        AFTER INSERT, UPDATE ON TapSetting
        EXECUTE PROCEDURE Udb_Change$Electrical
        (   Object = New.Object
        );
    /*
     *      Specifications
     */

    /*
     *      Interactions
     */
    CREATE PROCEDURE Udb_Change$Connectivity
    (   Object                      INTEGER
    ) =
        DECLARE
            PrimaryGroupingName VARCHAR(20) NOT NULL;
```

```
        TypeName                VARCHAR(20) NOT NULL;
        Name                    VARCHAR(20) NOT NULL;
        EventText               VARCHAR(256) NOT NULL;
    BEGIN
        SELECT  :PrimaryGroupingName = O.PrimaryGroupingName,
                :TypeName = O.TypeName,
                :Name = O.Name
        FROM    Object O
        WHERE   :Object = O.Object;
        EventText = SQUEEZE (PrimaryGroupingName + ' ' + TypeName + ' ' + Name
        RAISE DBEVENT Udb_ChangeConnectivity :EventText;
    END;

CREATE RULE Udb_Change$Terminal
    AFTER INSERT, UPDATE ON Terminal
    WHERE   Old.Node != New.Node
    EXECUTE PROCEDURE Udb_Change$Connectivity
    (   Object = New.Object
    );
```

```
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*****************************************************************************/

/*
 *      Generic reject procedure
 */
CREATE PROCEDURE Reject (Problem VARCHAR(20) NOT NULL) =
    BEGIN
        INSERT INTO GrassCatcher (Object, Problem)
            VALUES (0, :Problem);
    END;
/*
 *      Object table
 */
/*
 *      Sort out an object on insert
 */
CREATE PROCEDURE Object$Insert
(   Tid                 INTEGER
,   Object              INTEGER
,   SystemVersion       INTEGER
,   Type                INTEGER
,   PrimaryGrouping     INTEGER
,   Terminals           INTEGER
) =
    DECLARE
        BaseType        INTEGER;
        TableName       VARCHAR(20);
        Loop            INTEGER;
        AddGrouping     INTEGER;

    BEGIN
/*
 *      Get the base type from the type. If neither is good, reject
 *      the insert.
 */
        SELECT  :BaseType = BT.Type,
                :TableName = BT.TableName
        FROM    Type T,
                BaseType BT
        WHERE   :Type = T.Type AND
                T.BaseType = BT.Type;

        IF BaseType = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Object_012');
        ENDIF;
/*
 *      Set up the key for the object if one was not supplied, and ensure
 *      that the object is in its primary group
```

```
*/
        AddGrouping = 0;

        IF Object = -1 THEN
            UPDATE  LastKey K
            SET     Value = K.Value + 1
            WHERE   K.LastKey = 'Object';

            SELECT  :Object = K.Value
            FROM    LastKey K
            WHERE   K.LastKey = 'Object';

            IF PrimaryGrouping != 0 THEN
                AddGrouping = 1;
            ENDIF;

        ENDIF;
/*
 *      Set the object key and base type.
 *      Get the type name from the type record and
 *      get the primary grouping name from its object record.
 *      Set up the creation date and user
 */
        UPDATE  Object O
        FROM    Type T,
                Object PG
        SET     Object = :Object,
                BaseType = :BaseType,
                TypeName = T.Name,
                PrimaryGroupingName = PG.Name,
                Created = 'Now',
                CreatedBy = VARCHAR (User)
        WHERE   :Type = T.Type AND
                :PrimaryGrouping = PG.Object AND
                :Tid = O.Tid;

        IF AddGrouping = 1 THEN
            INSERT INTO Grouping
                (SystemVersion
                ,Grouping
                ,Member
                ,Relationship
                )
            VALUES
                (:SystemVersion
                ,:PrimaryGrouping
                ,:Object
                ,52     /* Type$member_of */
                );
        ENDIF;
/*
 *      Insert terminals for the object
 */
        Loop = 1;

        WHILE Loop <= Terminals DO
            INSERT INTO Terminal
                (Object
                ,BaseType
                ,Terminal
                )
            VALUES
                (:Object
                ,:BaseType
                ,:Loop
                );
```

```
            Loop = Loop + 1;
        ENDWHILE;
/*
 *      Insert the associated type specific row (if any)
 */
        IF TableName = '' THEN
            TableName = TableName;  /* Do nothing */
        ELSEIF TableName = 'Generator' THEN
            INSERT INTO Generator (Object) VALUES (:Object);
        ELSEIF TableName = 'Consumer' THEN
            INSERT INTO Consumer (Object) VALUES (:Object);
        ELSEIF TableName = 'Capacitor' THEN
            INSERT INTO Capacitor (Object) VALUES (:Object);
        ELSEIF TableName = 'Reactor' THEN
            INSERT INTO Reactor (Object) VALUES (:Object);
        ELSEIF TableName = 'Switch' THEN
            INSERT INTO Switch (Object) VALUES (:Object);
        ELSEIF TableName = 'Transformer' THEN
            INSERT INTO Transformer (Object) VALUES (:Object);
        ELSEIF TableName = 'BreakerSensor' THEN
            TableName = TableName;  /*** NYI ***/
        ELSEIF TableName = 'Telemetry' THEN
            INSERT INTO Telemetry (Object) VALUES (:Object);
        ELSEIF TableName = 'TowerType' THEN
            INSERT INTO TowerType (Object) VALUES (:Object);
        ELSEIF TableName = 'ConductorType' THEN
            INSERT INTO ConductorType (Object) VALUES (:Object);
        ELSEIF TableName = 'Conductor' THEN
            INSERT INTO Conductor (Object) VALUES (:Object);
        ELSEIF TableName = 'Computer' THEN
            INSERT INTO Computer (Object) VALUES (:Object);
        ELSEIF TableName = 'Person' THEN
            INSERT INTO Person (Object) VALUES (:Object);
        ENDIF;

    END;
/*
 *      Do validation on an object
 */
CREATE PROCEDURE Object$Validate
(   Object      INTEGER
,   InService   DATE
,   OutService  DATE
) =
    BEGIN

        IF InService > OutService THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Object_001');
        ENDIF;

    END;
/*
 *      Maintain the PrimaryGroupingName in the objects that reference
 *      this one as their primary group
 */
CREATE PROCEDURE Object$Name
(   Tid         INTEGER
,   BaseType    INTEGER
) =
    BEGIN
        UPDATE  Object O
        FROM    Object PG
        SET     PrimaryGroupingName = PG.Name
        WHERE   :Tid = PG.Tid AND
                PG.Object = O.PrimaryGrouping;
```

```
    END;
/*
 *      Maintain the TypeName in the Object
 */
CREATE PROCEDURE Object$TypeName
(   Tid     INTEGER
) =
    BEGIN

        UPDATE  Object O
        FROM    Type T
        SET     TypeName = T.Name
        WHERE   T.Type = O.Type AND
                O.Tid = :Tid;

    END;
/*
 *      Ensure that the object always belongs to its primary group.
 *      If the object is a Consumer, then update the load model.
 */
CREATE PROCEDURE Object$PrimaryGrouping
(   Tid                 INTEGER
,   Object              INTEGER
,   SystemVersion       INTEGER
,   Old_PrimaryGrouping INTEGER
,   New_PrimaryGrouping INTEGER
) =
    DECLARE
        References      INTEGER NOT NULL;
    BEGIN
/*
 *      If there is a primary grouping defined, ensure that the
 *      object exists as a member of the group
 */
        IF New_PrimaryGrouping != 0 THEN

            SELECT  :References = COUNT(*)
            FROM    Grouping G
            WHERE   :New_PrimaryGrouping = G.Grouping AND
                    :Object = G.Member;

            IF References = 0 THEN
                INSERT INTO Grouping
                    (SystemVersion
                    ,Grouping
                    ,Member
                    ,Relationship
                    )
                VALUES
                    (:SystemVersion
                    ,:New_PrimaryGrouping
                    ,:Object
                    ,52     /* TypeSmember_of */
                    );
            ENDIF;

        ENDIF;
/*
 *      Ensure that the primary grouping name for the object is correct
 */
        UPDATE  Object O
        FROM    Object PG
        SET     PrimaryGroupingName = PG.Name
        WHERE   :New_PrimaryGrouping = PG.Object AND
                O.Tid = :Tid;
/*
```

```
*       Blindly update the load model. Nothing will happen unless this object
*       is a consumer and the primary grouping is also a consumer.
*       If this consumer has been detached from a higher level part of the
*       load model, set its percentages to 100.
*/
        UPDATE  Consumer LM
        FROM    Consumer C
        SET     Pfixed = IFNULL(LM.PFixed,0) - IFNULL(C.Pfixed,0),
                Pnom =  IFNULL(LM.Pnom,0) - IFNULL(C.Pnom,0),
                Qfixed = IFNULL(LM.QFixed,0) - IFNULL(C.Qfixed,0),
                Qnom =  IFNULL(LM.Qnom,0) - IFNULL(C.Qnom,0)
        WHERE   :Object = C.Object AND
                :Old_PrimaryGrouping = LM.Object;

        UPDATE  Consumer LM
        FROM    Consumer C
        SET     Pfixed = IFNULL(LM.PFixed,0) + IFNULL(C.Pfixed,0),
                Pnom = IFNULL(LM.Pnom,0) + IFNULL(C.Pnom,0),
                Qfixed = IFNULL(LM.QFixed,0) + IFNULL(C.Qfixed,0),
                Qnom = IFNULL(LM.Qnom,0) + IFNULL(C.Qnom,0)
        WHERE   :Object = C.Object AND
                :New_PrimaryGrouping = LM.Object;

        IF IIRowCount = 0 THEN
            UPDATE  Consumer C
            SET     PfixedPct = 100,
                    PnomPct = 100,
                    QfixedPct = 100,
                    QnomPct = 100
            WHERE   :Object = C.Object;
        ENDIF;

    END;
/*
*       Conducting plant validation
*/
CREATE PROCEDURE Conductor$Validate
(   Object              INTEGER
,   R                   REAL
,   X                   REAL
,   Bch                 REAL
) =
    BEGIN

        IF (X / R) < 5 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Conductor_001');
        ENDIF;

    END;
/*
*       Update the load model when a consumer is changed
*/
CREATE PROCEDURE Consumer$UpdateLoadModel
(   Object              INTEGER
,   Old_Pfixed          REAL
,   New_Pfixed          REAL
,   Old_Pnom            REAL
,   New_Pnom            REAL
,   Old_Qfixed          REAL
,   New_Qfixed          REAL
,   Old_Qnom            REAL
,   New_Qnom            REAL
) =
    BEGIN
/*
```

```
*       Recursively update the hierarchy of consumers in the load model
*       from the bottom up. This will stop when an object that is not a
*       consumer is encountered
*/
        UPDATE  Consumer LM
        FROM    Object O
        SET     Pfixed = IFNULL(LM.PFixed,0) +
                         (IFNULL(New_Pfixed,0) - IFNULL(Old_Pfixed,0)),
                Pnom = IFNULL(LM.Pnom,0) +
                         (IFNULL(New_Pnom,0) - IFNULL(Old_Pnom,0)),
                Qfixed = IFNULL(LM.QFixed,0) +
                         (IFNULL(New_Qfixed,0) - IFNULL(Old_Qfixed,0)),
                Qnom = IFNULL(LM.Qnom,0) +
                         (IFNULL(New_Qnom,0) - IFNULL(Old_Qnom,0))
        WHERE   :Object = O.Object AND
                O.PrimaryGrouping = LM.Object;
/*
*       If we have hit the top this consumer represents 100% of the
*       load in its hierarchy. Set this up to trigger a re-calculation
*       of all the child consumer percentages.
*/
        IF IIRowCount = 0 THEN
            UPDATE  Consumer C
            SET     PfixedPct = 100,
                    PnomPct = 100,
                    QfixedPct = 100,
                    QnomPct = 100,
                    TopLoadArea = C.Object
            WHERE   :Object = C.Object;
        ENDIF;

    END;
/*
*       Update the distribution of the loads by percentage from the
*       top down.
*/
CREATE PROCEDURE Consumer$UpdateLoadPct
(   Object              INTEGER
,   Pfixed              REAL
,   Pnom                REAL
,   Qfixed              REAL
,   Qnom                REAL
,   PfixedPct           REAL
,   PnomPct             REAL
,   QfixedPct           REAL
,   QnomPct             REAL
,   TopLoadArea         INTEGER
) =
    BEGIN
/*
*       If there is the possibility of a divide by zero, then use a trash
*       (but safe) value as the divisor, and force the result to zero
*/
        IF ABS(Pfixed) < 0.0000001 THEN
            PFixed = 1;
            PFixedPct = 0;
        ENDIF;

        IF ABS(Pnom) < 0.0000001 THEN
            PNom = 1;
            PNomPct = 0;
        ENDIF;

        IF ABS(Qfixed) < 0.0000001 THEN
            QFixed = 1;
            QFixedPct = 0;
```

```
        ENDIF;

        IF ABS(Qnom) < 0.0000001 THEN
            QNom = 1;
            QNomPct = 0;
        ENDIF;
/*
 *      Recalculate the child percentages
 */
        UPDATE  Consumer C
        FROM    Object O
        SET     PfixedPct = (C.Pfixed / :Pfixed) * :PfixedPct,
                PnomPct = (C.Pnom / :Pnom) * :PnomPct,
                QfixedPct = (C.Qfixed / :Qfixed) * :QfixedPct,
                QnomPct = (C.Qnom / :Qnom) * :QnomPct,
                TopLoadArea = :TopLoadArea
        WHERE   :Object = O.PrimaryGrouping AND
                O.Object = C.Object;
    END;
/*
 *      Ensure that the winding belongs to a transformer and
 *      get the next sequence number
 */
CREATE PROCEDURE Winding$Insert
(   Tid                 INTEGER
,   Object              INTEGER
,   KVLevel             REAL
) =
    DECLARE
        BaseType            INTEGER;
        References          INTEGER     NOT NULL;
        MaxSeq              INTEGER;

    BEGIN

        SELECT  :BaseType = O.BaseType
        FROM    Object O
        WHERE   :Object = O.Object;

        IF BaseType != 27 THEN  /* Type$Transformer */
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Transformer_008');
        ENDIF;
/*
 *    Get a sequence number for the winding
 */
        SELECT  MaxSeq = MAX(Winding)
        FROM    Winding
        WHERE   Object = :Object;

        IF MaxSeq IS NULL THEN
            MaxSeq = 1;
        ELSE
            MaxSeq = MaxSeq + 1;
        ENDIF;
/*
 *    Update the number of terminals for the transformer
 */
        UPDATE  Object
        SET     Terminals = Terminals + 1
        WHERE   Object = :Object;

        INSERT INTO Terminal
            (Object
            ,BaseType
            ,Terminal
```

```
            ,KVLevel
            )
        VALUES
            (:Object
            ,:BaseType
            ,:MaxSeq
            ,:KVLevel
            );
/*
 *    Update the winding last cos it can change the Tid
 */
        UPDATE  Winding
        SET     Winding = :MaxSeq
        WHERE   Tid = :Tid;

    END;
/*
 *    Validate the attributes of a winding
 */
CREATE PROCEDURE Winding$Validate
(   Object                  INTEGER
,   Name                    CHAR(10)
,   LoadTapChanger          INTEGER
,   NominalKV               REAL
,   NeutralKV               REAL
,   LowStep                 INTEGER
,   HighStep                INTEGER
,   NeutralStep             INTEGER
,   StepSize                REAL
) =
    DECLARE
        Steps               INTEGER;
        KVDiff              REAL;

    BEGIN

        IF LoadTapChanger != 0 AND LoadTapChanger != 1 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (:Object, Name, 'Transformer_003');
        ENDIF;

        IF LowStep > HighStep THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (:Object, Name, 'Transformer_004');
        ENDIF;

        IF NeutralStep < LowStep THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (:Object, Name, 'Transformer_005');
        ENDIF;

        IF NeutralStep > HighStep THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (:Object, Name, 'Transformer_006');
        ENDIF;

        IF StepSize = 0 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (:Object, Name, 'Transformer_007');
        ENDIF;

        IF NeutralKV = NominalKV THEN
            Steps = 0;
        ELSEIF NeutralKV > NominalKV THEN
            Steps = LowStep - NeutralStep;  /* negative steps to get there */
        ELSEIF NeutralKV < NominalKV THEN
```

```
        Steps = HighStep - NeutralStep; /* positive steps to get there *
    ENDIF;

    KVDiff =  ABS (Steps * StepSize * NeutralKV / 100);
    KVDiff = KVDiff + (NeutralKV * 0.10);   /* Allow 10% overdrive */

    IF KVDiff < ABS(NeutralKV - NominalKV) THEN
        INSERT INTO GrassCatcher (Object, Text, Problem)
            VALUES (:Object, Name, 'Transformer_001');
    ENDIF;

    IF StepSize > 10 THEN
        INSERT INTO GrassCatcher (Object, Text, Problem)
            VALUES (:Object, Name, 'Transformer_002');
    ENDIF;

END;
/*
 *    Clean up on delete of a winding
 */
CREATE PROCEDURE Winding$Delete
(   Object              INTEGER
,   Winding             INTEGER
) =
BEGIN
/*
 *    Reduce the number of terminals for this transformer
 */
    DELETE FROM Terminal
    WHERE   Object = :Object AND
            Terminal = :Winding;

    UPDATE  Object
    SET     Terminals = Terminals - :IIRowCount
    WHERE   Object = :Object;

    END;
/*
 *    Validate the attributes for a tap setting
 */
CREATE PROCEDURE TapSetting$Validate
(   Object              INTEGER
,   Winding1            INTEGER
,   TapStep1            INTEGER
,   Winding2            INTEGER
,   TapStep2            INTEGER
,   Winding3            INTEGER
,   TapStep3            INTEGER
) =
    DECLARE
    LowStep             INTEGER     WITH NULL;
    HighStep            INTEGER     WITH NULL;

    BEGIN

        LowStep = NULL;
        HighStep = NULL;

        SELECT  :LowStep = W.LowStep,
                :HighStep = W.HighStep
        FROM    Winding W
        WHERE   W.Object = :Object AND
                W.Winding = :Winding1;

        IF LowStep IS NULL AND HighStep IS NULL THEN
            INSERT INTO GrassCatcher (Object, Problem)
```

```
            VALUES (:Object, 'Transformer_009');
        ELSEIF TapStep1 < LowStep OR TapStep1 > HighStep THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Transformer_010');
        ENDIF;

        LowStep = NULL;
        HighStep = NULL;

        SELECT  :LowStep = W.LowStep,
                :HighStep = W.HighStep
        FROM    Winding W
        WHERE   W.Object = :Object AND
                W.Winding = :Winding2;

        IF LowStep IS NULL AND HighStep IS NULL THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Transformer_009');
        ELSEIF TapStep2 < LowStep OR TapStep2 > HighStep THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Transformer_010');
        ENDIF;

        LowStep = NULL;
        HighStep = NULL;

        SELECT  :LowStep = W.LowStep,
                :HighStep = W.HighStep
        FROM    Winding W
        WHERE   W.Object = :Object AND
                W.Winding = :Winding3;

        IF LowStep IS NULL AND HighStep IS NULL THEN
            /* May not be a three way measurement */
            LowStep = HighStep;     /* Empty statement blocks not allowed! */
        ELSEIF TapStep3 < LowStep OR TapStep3 > HighStep THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Transformer_010');
        ENDIF;

    END;
/*
 *      Specifications
 */
/*
 *      Get the surrogate key set up on inserts
 */
CREATE PROCEDURE LoadCurve$Insert
(   Tid         INTEGER
,   LoadCurve   INTEGER
) =
    BEGIN

        IF LoadCurve = -1 THEN
            UPDATE  LastKey
            SET     Value = Value + 1
            WHERE   LastKey = 'Curves';

            UPDATE  LoadCurve C
            FROM    LastKey K
            SET     LoadCurve = K.Value
            WHERE   C.Tid = :Tid AND
                    K.LastKey = 'Curves';
        ENDIF;

    END;
```

```
/*
 *      Check the referenced types exist on inserts
 */
CREATE PROCEDURE SuperType$Insert
(    Type INTEGER
,    SuperType INTEGER
) =
    DECLARE
        References          INTEGER NOT NULL;

    BEGIN

        SELECT  :References = COUNT(*)
        FROM    Type
        WHERE   Type = :Type;

        IF References = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (0, 'Type_004');
        ENDIF;

        SELECT  :References = COUNT(*)
        FROM    Type
        WHERE   Type = :SuperType;

        IF References = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (0, 'Type_005');
        ENDIF;
/*
 *        Insert the type and all its supertypes as
 *        supertypes in the extended type list
 */
        INSERT INTO ExtendedType
            (Type
            ,SuperType
            )
        VALUES
            (:Type
            ,:Type
            );

        INSERT INTO ExtendedType
            (Type
            ,SuperType
            )
        SELECT  :Type,
                SuperType
        FROM    ExtendedType
        WHERE   Type = :SuperType;

    END;
/*
 *      Ensure that there are no references to the sub-type on delete
 */
CREATE PROCEDURE SuperType$Delete
(    Type    INTEGER
) =
    DECLARE
        References  INTEGER NOT NULL;
        Name        CHAR(20) NOT NULL;

    BEGIN

        SELECT  :Name = T.Name
        FROM    Type T
```

```
        WHERE   :Type = T.Type;

        SELECT  :References = COUNT(*)
        FROM    SuperType ST
        WHERE   :Type = ST.SuperType;

        IF References != 0 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (0, :Name, 'Type_001');
        ENDIF;

        SELECT  :References = COUNT(*)
        FROM    Object O
        WHERE   :Type = O.Type;

        IF References != 0 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (0, :Name, 'Type_002');
        ENDIF;

        DELETE FROM ExtendedType
        WHERE   :Type = Type;

    END;
/*
 *      Get the surrogate key set up on inserts
 */
CREATE PROCEDURE Type$Insert
(   Tid         INTEGER
,   Type        INTEGER
) =
    BEGIN

        IF Type = -1 THEN
            UPDATE  LastKey
            SET     Value = Value + 1
            WHERE   LastKey = 'Type';

            UPDATE  Type C
            FROM    LastKey K
            SET     Type = K.Value
            WHERE   C.Tid = :Tid AND
                    K.LastKey = 'Type';
        ENDIF;

    END;
/*
 *      Prevent delete if the type is referenced in the
 *      super-type - sub-type heirarchy
 */
CREATE PROCEDURE Type$Delete
(   Type        INTEGER
,   Name        VARCHAR(20)
) =
    DECLARE
        References  INTEGER NOT NULL;
    BEGIN
/*
 *      Verify that the Type is not a system type
 */
        IF Type < 10000 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (0, :Name, 'Type_003');
        ENDIF;
/*
 *      Verify that the Type is not a supertype
```

```
    */
        SELECT  :References = COUNT(*)
        FROM    SuperType
        WHERE   SuperType = :Type;

        IF References != 0 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (0, :Name, 'Type_001');
        ENDIF;
    END;
/*
 *      Propagate any change to the value of a kVLevel
 */
CREATE PROCEDURE kVLevel$Update_kVLevel
(   Old_kVLevel     REAL
,   New_kVLevel     REAL
) =
    BEGIN
        UPDATE  Terminal T
        SET     kVLevel = :New_kVLevel
        WHERE   :Old_kVLevel = T.kVLevel;
    END;
/*
 *      Block delete of a kVLevel if there are any
 *      terminals at that voltage
 */
CREATE PROCEDURE kVLevel$Delete
(   kVLevel         REAL
) =
    DECLARE
        References  INTEGER NOT NULL;
    BEGIN
        SELECT  :References = COUNT(*)
        FROM    Terminal T
        WHERE   :kVLevel = T.kVLevel;

        IF References != 0 THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (0, VARCHAR(:kVLevel), 'Object_002');
        ENDIF;

    END;
/*
 *      Propagate the transformer terminal voltage levels across all the
 *      connected terminals.
 */
CREATE PROCEDURE kVLevel$Propagate
=
    DECLARE
        stext           varchar(40) not null;
        Loop            INTEGER NOT NULL;
        MaxIterations   INTEGER NOT NULL;
    BEGIN
        DELETE FROM TEMP$TerminalList;
        DELETE FROM TEMP$ObjectList;
        DELETE FROM TEMP$AuditTrail;
/*
 *      Build a list of all the transformer terminals to use as a start point,
 *      and record the fact that they have been processed.
 */
        INSERT INTO TEMP$TerminalList
        SELECT  *
        FROM    Terminal
        WHERE   BaseType = 27;          /* Type$Transformer */

        INSERT INTO TEMP$AuditTrail
```

```
        SELECT  Object
        FROM    TEMP$TerminalList;
/*
 *      Loop, looking for new objects, and set their terminal kV levels up
 *      when they are found
 */
        Loop = 1;
        MaxIterations = 40;

        WHILE Loop <= MaxIterations DO
/*
 *      Get a list of all the objects connected to the terminals in the
 *      terminal list, propagating the voltage from the terminal list
 */
            DELETE FROM TEMP$ObjectList;
            INSERT INTO TEMP$ObjectList
                (Object
                ,kVLevel
                )
            SELECT DISTINCT
                T.Object,
                TL.kVLevel
            FROM    Terminal T,
                    TEMP$TerminalList TL
            WHERE   TL.Node = T.Node AND            /* same node */
                    TL.Object != T.Object;          /* different object */
/*
 *      Discard any that have already been visited, set the voltage levels
 *      for all the terminals of those that remain, and add them to the
 *      audit trail
 */
            DELETE FROM TEMP$ObjectList OL
            WHERE   OL.Object = (SELECT Object FROM TEMP$AuditTrail);

            UPDATE  Terminal T
            FROM    TEMP$ObjectList OL
            SET     kVLevel = OL.kVLevel
            WHERE   T.Object = OL.Object AND        /* object in object list */
                    T.Node >= 10000;                /* not a system node */

            INSERT INTO TEMP$AuditTrail
            SELECT  DISTINCT Object
            FROM    TEMP$ObjectList;
/*
 *      Find all the other terminals for these objects
 */
            DELETE FROM TEMP$TerminalList;
            INSERT INTO TEMP$TerminalList
            SELECT DISTINCT T.*
            FROM    Terminal T,
                    TEMP$ObjectList OL
            WHERE   OL.Object = T.Object AND        /* same object */
                    T.Node >= 10000;                /* not a system node */

            IF IIRowCount = 0 THEN
                ENDLOOP;
            ENDIF;

            Loop = Loop + 1;
        ENDWHILE;
/*
create table objectlist as
    select  object
    from    object
    where   basetype != 27 and
            terminals > 1;
```

```
select  ol.object
from    objectlist ol,
        terminal t1,
        terminal t2
where   ol.object = TEMP$objectlist.object and
        ol.object = t2.object and
        t1.terminal != t2.terminal and
        t1.node >= 10000 and
        t2.node >= 10000 and
        t1.kvlevel != t2.kvlevel;
*/
    END;
/*
 *      Interactions
 */
/*
 *      Check that not too many terminals are being used
 */
CREATE PROCEDURE Terminal$Validate
(   Tid INTEGER
,   Object INTEGER
) =
    DECLARE
        References      INTEGER;
        MaxTerm         INTEGER;
    BEGIN
        SELECT  :References = COUNT(*)
        FROM    Terminal
        WHERE   Object = :Object AND
                Terminal > 0;

        SELECT  :MaxTerm = Terminals
        FROM    Object
        WHERE   Object = :Object;

        IF References > MaxTerm THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:Object, 'Object_003');
        ENDIF;

    END;
/*
 *    Check the referenced objects exist on inserts
 */
CREATE PROCEDURE Grouping$Insert
    (Tid                INTEGER
    ,Grouping           INTEGER
    ,Member             INTEGER
    ) =
    DECLARE
        GroupingType        INTEGER     WITH NULL;
        MemberType          INTEGER     WITH NULL;
    BEGIN
        GroupingType = NULL;

        SELECT  :GroupingType = Type
        FROM    Object
        WHERE   Object = :Grouping;

        IF GroupingType IS NULL THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (0, 'Object_004');
        ENDIF;

        MemberType = NULL;
```

```
        SELECT  :MemberType = Type
        FROM    Object
        WHERE   Object = :Member;

        IF MemberType IS NULL THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (0, 'Object_005');
        ENDIF;

        UPDATE  Grouping
        SET     GroupingType = :GroupingType,
                MemberType = :MemberType
        WHERE   :Tid = Tid;
    END;

CREATE PROCEDURE GrassCatcher$Insert
    (Tid             INTEGER
    ,Object          INTEGER
    ,Problem         CHAR(20)
    ,Text            CHAR(20)
    )=
    DECLARE
        References  INTEGER     NOT NULL;
        Description CHAR(60)    NOT NULL;
        Severity    CHAR(1)     NOT NULL;
    BEGIN
/*
 *      Get rid of this entry if it is a duplicate
 */
        SELECT  :References = COUNT(*)
        FROM    GrassCatcher
        WHERE   :Object = Object AND
                :Problem = Problem AND
                :Text = Text;

        IF References > 1 THEN
            DELETE FROM GrassCatcher
            WHERE   :Tid = Tid;
        ENDIF;
/*
 *      Show the problem description, and blow the transaction away
 *      if the error is fatal
 */
        SELECT  :Description = P.Description,
                :Severity = P.Severity
        FROM    Problem P
        WHERE   :Problem = P.Problem;

        IF Severity = 'F' THEN
            RAISE ERROR -1 Description;
        ELSE
            MESSAGE 0 Description;
        ENDIF;

    END;
```

```
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*****************************************************************************/

/*
 *      This file contain rules that fire in order to ensure referential
 *      integrity. Typically, there is one for an insert on every table:
 *      (TableName$Insert1) and one for a deletion on every table:
 *      (TableName$Delete). There also may be a rule that fires on an
 *      update of a specific column (TableName$Update_ColumnName) if that
 *      change requires a check on the REFERENTIAL validity of the
 *      modification.
 *
 *      The rules in this file are required to be active.
 */
/*
 *      Object table
 */
CREATE RULE Object$Insert1
    AFTER INSERT ON Object
    EXECUTE PROCEDURE Object$Insert
    (   Tid = New.Tid
    ,   Object = New.Object
    ,   SystemVersion = New.SystemVersion
    ,   Type = New.Type
    ,   PrimaryGrouping = New.PrimaryGrouping
    ,   Terminals = New.Terminals
    );
CREATE RULE Object$Delete
    AFTER DELETE ON Object
    EXECUTE PROCEDURE Reject
    (   Problem = 'Object_006'
    );
/*
 *      Conducting plant
 */
/*
 *      Transformer components
 */
CREATE RULE Winding$Insert1
    AFTER INSERT ON Winding
    EXECUTE PROCEDURE Winding$Insert
    (   Tid = New.Tid
    ,   Object = New.Object
    ,   KVLevel = New.NominalKV
    );
CREATE RULE Winding$Delete
    AFTER DELETE ON Winding
    EXECUTE PROCEDURE Winding$Delete
    (   Object = Old.Object
    ,   Winding = Old.Winding
```

```
    );
/*
 *      Specifications
 */
CREATE RULE LoadCurve$Insert1
    AFTER INSERT ON LoadCurve
    EXECUTE PROCEDURE LoadCurve$Insert
    (   Tid = New.Tid
    ,   LoadCurve = New.LoadCurve
    );
CREATE RULE LastKey$Delete
    AFTER DELETE ON LastKey
    EXECUTE PROCEDURE Reject
    (   Problem = 'Object_006'
    );
CREATE RULE SuperType$Insert1
    AFTER INSERT ON SuperType
    EXECUTE PROCEDURE SuperType$Insert
    (   Type = New.Type
    ,   SuperType = New.SuperType
    );
CREATE RULE SuperType$Delete
    AFTER DELETE ON SuperType
    EXECUTE PROCEDURE SuperType$Delete
    (   Type = Old.Type
    );
CREATE RULE Type$Insert1
    AFTER INSERT ON Type
    EXECUTE PROCEDURE Type$Insert
    (   Tid = New.Tid
    ,   Type = New.Type
    );
CREATE RULE Type$Delete
    AFTER DELETE ON Type
    EXECUTE PROCEDURE Type$Delete
    (   Type = Old.Type
    ,   Name = Old.Name
    );
CREATE RULE kVLevel$Update_kVLevel
    AFTER UPDATE (kVLevel) ON kVLevel
    EXECUTE PROCEDURE kVLevel$Update_kVLevel
    (   Old_kVLevel = Old.kVLevel
    ,   New_kVLevel = New.kVLevel
    );
CREATE RULE kVLevel$Delete
    AFTER DELETE ON kVLevel
    EXECUTE PROCEDURE kVLevel$Delete
    (   kVLevel = Old.kVLevel
    );
/*
 *      Interactions
 */
CREATE RULE Grouping$Insert1
    AFTER INSERT ON Grouping
    EXECUTE PROCEDURE Grouping$Insert
    (   Tid = New.Tid
    ,   Grouping = New.Grouping
    ,   Member = New.Member
    );
```

```
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*****************************************************************************/

/*
 *      This file contain rules that fire in order to ensure internal
 *      validity of the data in a row. Typically, there is one for an
 *      insert on every table: (TableName$Insert2).There also may be a
 *      rule that fires on an update of a specific column:
 *      (TableName$Update_ColumnName) if that change requires a check
 *      on the internal validity of the modification.
 *
 *      The rules in this file are not required to be active. Although
 *      they ensure that the data in a row is valid (often electrically),
 *      they may be dropped to speed up bulk loading of data. Therefore
 *      every rule that is defined in this file must have a corresponding
 *      entry in the file "drop_rules_validation.sql", which can be
 *      executed to drop the rules when desired. A nawk program,
 *      create_to_drop.nawk exists for this purpose, and can be run
 *      with the command:
 *
 *      "nawk -f create_to_drop.nawk\
 *          create_rules_validation.sql\
 *          > drop_rules_validation.sql"
 */

/*
 *      Object table
 */
CREATE RULE Object$Insert2
    AFTER INSERT ON Object
    EXECUTE PROCEDURE Object$Validate
    (   Object = New.Object
    ,   InService = New.Inservice
    ,   OutService = New.OutService
    );
CREATE RULE Object$Update_Name
    AFTER UPDATE (Name) ON Object
    WHERE Old.Name != New.Name
    EXECUTE PROCEDURE Object$Name
    (   Tid = New.Tid
    ,   BaseType = New.BaseType
    );
CREATE RULE Object$Update_InService
    AFTER UPDATE (InService) ON Object
    WHERE Old.InService != New.InService
    EXECUTE PROCEDURE Object$Validate
    (   Object = New.Object
    ,   InService = New.Inservice
    ,   OutService = New.OutService
    );
```

```
CREATE RULE Object$Update_OutService
    AFTER UPDATE (OutService) ON Object
    WHERE Old.OutService != New.OutService
    EXECUTE PROCEDURE Object$Validate
    (   Object = New.Object
    ,   InService = New.Inservice
    ,   OutService = New.OutService
    );
CREATE RULE Object$Update_Type
    AFTER UPDATE (Type) ON Object
    WHERE Old.Type != New.Type
    EXECUTE PROCEDURE Object$TypeName
    (   Tid = New.Tid
    );
CREATE RULE Object$Update_PG
    AFTER UPDATE (PrimaryGrouping) ON Object
    WHERE Old.PrimaryGrouping != New.PrimaryGrouping
    EXECUTE PROCEDURE Object$PrimaryGrouping
    (   Tid = New.Tid
    ,   Object = New.Object
    ,   SystemVersion = New.SystemVersion
    ,   Old_PrimaryGrouping = Old.PrimaryGrouping
    ,   New_PrimaryGrouping = New.PrimaryGrouping
    );
/*
 *      Conducting plant
 */
CREATE RULE Conductor$Insert2
    AFTER INSERT ON Conductor
    EXECUTE PROCEDURE Conductor$Validate
    (   Object = New.Object
    ,   R = New.R
    ,   X = New.X
    ,   Bch = New.Bch
    );
CREATE RULE Conductor$Update
    AFTER UPDATE ON Conductor
    EXECUTE PROCEDURE Conductor$Validate
    (   Object = New.Object
    ,   R = New.R
    ,   X = New.X
    ,   Bch = New.Bch
    );
CREATE RULE Consumer$Insert2
    AFTER INSERT ON Consumer
    EXECUTE PROCEDURE Consumer$UpdateLoadModel
    (   Object = New.Object
    ,   Old_Pfixed = 0
    ,   New_Pfixed = New.Pfixed
    ,   Old_Pnom = 0
    ,   New_Pnom = New.Pnom
    ,   Old_Qfixed = 0
    ,   New_Qfixed = New.Qfixed
    ,   Old_Qnom = 0
    ,   New_Qnom = New.Qnom
    );
CREATE RULE Consumer$UpdatePQ
    AFTER UPDATE ON Consumer
    WHERE   Old.Pfixed != New.Pfixed OR
            Old.Pnom != New.Pnom OR
            Old.Qfixed != New.Qfixed OR
            Old.Qnom != New.Qnom
    EXECUTE PROCEDURE Consumer$UpdateLoadModel
    (   Object = New.Object
    ,   Old_Pfixed = Old.Pfixed
    ,   New_Pfixed = New.Pfixed
```

```
        ,   Old_Pnom = Old.Pnom
        ,   New_Pnom = New.Pnom
        ,   Old_Qfixed = Old.Qfixed
        ,   New_Qfixed = New.Qfixed
        ,   Old_Qnom = Old.Qnom
        ,   New_Qnom = New.Qnom
        );
CREATE RULE Consumer$UpdatePQPct
    AFTER UPDATE (PfixedPct) ON Consumer
    WHERE Old.Type = 91          /* Type$LoadArea */
    EXECUTE PROCEDURE Consumer$UpdateLoadPct
    (   Object = New.Object
    ,   Pfixed = New.Pfixed
    ,   Pnom = New.Pnom
    ,   Qfixed = New.Qfixed
    ,   Qnom = New.Qnom
    ,   PfixedPct = New.PfixedPct
    ,   PnomPct = New.PnomPct
    ,   QfixedPct = New.QfixedPct
    ,   QnomPct = New.QnomPct
    ,   TopLoadArea = New.TopLoadArea
    );
/*
 *      Transformer components
 */
CREATE RULE Winding$Insert2
    AFTER INSERT ON Winding
    EXECUTE PROCEDURE Winding$Validate
    (   Object = New.Object
    ,   Name = New.Name
    ,   LoadTapChanger = New.LoadTapChanger
    ,   NominalKV = New.NominalKV
    ,   NeutralKV = New.NeutralKV
    ,   LowStep = New.LowStep
    ,   HighStep = New.HighStep
    ,   NeutralStep = New.NeutralStep
    ,   StepSize = New.StepSize
    );
CREATE RULE Winding$Update
    AFTER UPDATE ON Winding
    EXECUTE PROCEDURE Winding$Validate
    (   Object = New.Object
    ,   Name = New.Name
    ,   LoadTapChanger = New.LoadTapChanger
    ,   NominalKV = New.NominalKV
    ,   NeutralKV = New.NeutralKV
    ,   LowStep = New.LowStep
    ,   HighStep = New.HighStep
    ,   NeutralStep = New.NeutralStep
    ,   StepSize = New.StepSize
    );
CREATE RULE TapSetting$Insert2
    AFTER INSERT ON TapSetting
    EXECUTE PROCEDURE TapSetting$Validate
    (   Object = New.Object
    ,   Winding1 = New.Winding1
    ,   TapStep1 = New.TapStep1
    ,   Winding2 = New.Winding2
    ,   TapStep2 = New.TapStep2
    ,   Winding3 = New.Winding3
    ,   TapStep3 = New.TapStep3
    );
CREATE RULE TapSetting$Update
    AFTER UPDATE ON TapSetting
    EXECUTE PROCEDURE TapSetting$Validate
    (   Object = New.Object
```

```
    ,   Winding1 = New.Winding1
    ,   TapStep1 = New.TapStep1
    ,   Winding2 = New.Winding2
    ,   TapStep2 = New.TapStep2
    ,   Winding3 = New.Winding3
    ,   TapStep3 = New.TapStep3
    );
/*
 *      Specifications
 */
/*
 *      Interactions
 */
CREATE RULE Terminal$Insert2
    AFTER INSERT ON Terminal
    EXECUTE PROCEDURE Terminal$Validate
    (   Tid = New.Tid
    ,   Object = New.Object
    );

CREATE RULE GrassCatcher$Insert2
    AFTER INSERT ON GrassCatcher
    EXECUTE PROCEDURE GrassCatcher$Insert
        (Tid = New.Tid
        ,Object = New.Object
        ,Problem = New.Problem
        ,Text = New.Text
        );
```

```
*****************************************************************************

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*****************************************************************************/

/*
 *  A base type is a position in the type hierarchy that identifies a number of
 *  subtypes that have similar attributes and behavior. Note that the type is a
 *  forward reference to an entry in the type table that may not be defined
 *  yet. This is preferable to allowing types to be defined with no checking on
 *  the validity of the base type. For each base type the name of the editor
 *  frame and the name of any detail table that is required may be defined.
*/
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (01, '', '');                          /* Type$Object */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (02, 'ObjectGeneric', '');             /* Type$Organization */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (18, 'ObjectGeneric', '');             /* Type$Ground */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (19, 'Conductor', 'Conductor');        /* Type$Busbar */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (20, 'Generator', 'Generator');        /* Type$Generator */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (21, 'Consumer', 'Consumer');          /* Type$Consumer */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (22, 'Conductor', 'Conductor');        /* Type$ACLineSegment */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (23, 'Conductor', 'Conductor');        /* Type$Jumper */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (24, 'Capacitor', 'Capacitor');        /* Type$Capacitor */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (25, 'Reactor', 'Reactor');            /* Type$Reactor */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (26, 'Switch', 'Switch');              /* Type$Switch */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (27, 'Transformer', 'Transformer');    /* Type$Transformer */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (31, 'BreakerSensor', '');             /* Type$Relay */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (35, 'Telemetry', 'Telemetry');        /* Type$Telemetry */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (43, 'TowerType', 'TowerType');        /* Type$TowerType */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (44, 'ConductorType', 'ConductorType'); /* Type$ConductorType */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (45, 'ObjectGeneric', '');             /* Type$RatingFamily */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (46, 'ObjectGeneric', '');             /* Type$LoadFamily */
INSERT INTO BaseType (Type, EditorName, TableName)
              VALUES (47, 'ObjectGeneric', '');             /* Type$Drawing */
INSERT INTO BaseType (Type, EditorName, TableName)
```

```
                VALUES (48, 'ObjectGeneric', '');          /* Type$Manufacturer *
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (49, 'ObjectGeneric', '');          /* Type$Season */
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (50, 'ObjectGeneric', '');          /* Type$DayType */
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (59, 'Conductor', 'Conductor');     /* Type$DCLineSegment *
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (60, 'Switch', 'Switch');           /* Type$Breaker */
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (61, 'Switch', 'Switch');           /* Type$Disconnect */
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (62, 'Switch', 'Switch');           /* Type$Fuse */
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (63, 'Computer', 'Computer');       /* Type$Computer */
INSERT INTO BaseType (Type, EditorName, TableName)
                VALUES (90, 'Person', 'Person');           /* Type$Person */
/*
 *  The following statements define the system types. Any entry added to the
 *  type table must be duplicated with an entry of a constant in the
 *  PowerSystemModel application with the name "Type$xxxx" and the integer
 *  value set to the value defined here.
 *
 *  The type table contains the type, the base type and the type name for
 *  each type. The type must be unique; the name should be unique but this
 *  is not enforced. A base type of 0 implies that the type is for
 *  classification only: an object of that type cannot be created or edited.
 *  If the base type is non-zero the type of the object can be freely changed
 *  amongst others which are subtypes of the base type. Note that it is
 *  possible to create a heirarchy of types that can only be descended.
 *
 *  New entries must be added at the end of the list, with the next highest
 *  type number. For each new entry in the type table, its immediate supertype
 *  must be defined in the supertype table. These definitions are grouped
 *  after the type table definitions.
 */
INSERT INTO Type (Type, BaseType, Name) VALUES (00, 01, '');
INSERT INTO Type (Type, BaseType, Name) VALUES (01, 01, 'Object');
INSERT INTO Type (Type, BaseType, Name) VALUES (02, 02, 'Organization');
INSERT INTO Type (Type, BaseType, Name) VALUES (03, 02, 'Company');
INSERT INTO Type (Type, BaseType, Name) VALUES (04, 02, 'Division');
INSERT INTO Type (Type, BaseType, Name) VALUES (05, 02, 'Substation');
INSERT INTO Type (Type, BaseType, Name) VALUES (06, 02, 'Bay');
INSERT INTO Type (Type, BaseType, Name) VALUES (07, 02, 'System');
INSERT INTO Type (Type, BaseType, Name) VALUES (08, 02, 'Spares');
INSERT INTO Type (Type, BaseType, Name) VALUES (09, 63, 'RTU');
INSERT INTO Type (Type, BaseType, Name) VALUES (10, 02, 'Line');
INSERT INTO Type (Type, BaseType, Name) VALUES (11, 02, 'Circuit');
INSERT INTO Type (Type, BaseType, Name) VALUES (12, 02, 'TransformerBank');
INSERT INTO Type (Type, BaseType, Name) VALUES (13, 02, 'CapacitorBank');
INSERT INTO Type (Type, BaseType, Name) VALUES (14, 01, 'Equipment');
INSERT INTO Type (Type, BaseType, Name) VALUES (15, 00, 'Template');
INSERT INTO Type (Type, BaseType, Name) VALUES (16, 01, 'Support');
INSERT INTO Type (Type, BaseType, Name) VALUES (17, 01, 'Conducting');
INSERT INTO Type (Type, BaseType, Name) VALUES (18, 18, 'Ground');
INSERT INTO Type (Type, BaseType, Name) VALUES (19, 19, 'Busbar');
INSERT INTO Type (Type, BaseType, Name) VALUES (20, 20, 'Generator');
INSERT INTO Type (Type, BaseType, Name) VALUES (21, 21, 'Consumer');
INSERT INTO Type (Type, BaseType, Name) VALUES (22, 22, 'ACLineSegment');
INSERT INTO Type (Type, BaseType, Name) VALUES (23, 23, 'Jumper');
INSERT INTO Type (Type, BaseType, Name) VALUES (24, 24, 'Capacitor');
INSERT INTO Type (Type, BaseType, Name) VALUES (25, 25, 'Reactor');
INSERT INTO Type (Type, BaseType, Name) VALUES (26, 26, 'Switch');
INSERT INTO Type (Type, BaseType, Name) VALUES (27, 27, 'Transformer');
INSERT INTO Type (Type, BaseType, Name) VALUES (28, 27, 'PowerTransformer');
INSERT INTO Type (Type, BaseType, Name) VALUES (29, 27, 'PhaseShifter');
```

```
INSERT INTO Type (Type, BaseType, Name) VALUES (30, 01, 'Sensing');
INSERT INTO Type (Type, BaseType, Name) VALUES (31, 01, 'Relay');
INSERT INTO Type (Type, BaseType, Name) VALUES (32, 31, 'VoltageRelay');
INSERT INTO Type (Type, BaseType, Name) VALUES (33, 31, 'FrequencyRelay');
INSERT INTO Type (Type, BaseType, Name) VALUES (34, 31, 'CurrentRelay');
INSERT INTO Type (Type, BaseType, Name) VALUES (35, 35, 'Telemetry');
INSERT INTO Type (Type, BaseType, Name) VALUES (36, 35, 'Analog');
INSERT INTO Type (Type, BaseType, Name) VALUES (37, 35, 'Digital');
INSERT INTO Type (Type, BaseType, Name) VALUES (38, 35, 'Counter');
INSERT INTO Type (Type, BaseType, Name) VALUES (39, 35, 'Control');
INSERT INTO Type (Type, BaseType, Name) VALUES (40, 21, 'Feeder');
INSERT INTO Type (Type, BaseType, Name) VALUES (41, 21, 'Load');
INSERT INTO Type (Type, BaseType, Name) VALUES (42, 01, 'Specification');
INSERT INTO Type (Type, BaseType, Name) VALUES (43, 43, 'TowerType');
INSERT INTO Type (Type, BaseType, Name) VALUES (44, 44, 'ConductorType');
INSERT INTO Type (Type, BaseType, Name) VALUES (45, 45, 'RatingFamily');
INSERT INTO Type (Type, BaseType, Name) VALUES (46, 46, 'LoadFamily');
INSERT INTO Type (Type, BaseType, Name) VALUES (47, 47, 'Drawing');
INSERT INTO Type (Type, BaseType, Name) VALUES (48, 48, 'Manufacturer');
INSERT INTO Type (Type, BaseType, Name) VALUES (49, 49, 'Season');
INSERT INTO Type (Type, BaseType, Name) VALUES (50, 50, 'DayType');
INSERT INTO Type (Type, BaseType, Name) VALUES (51, 00, 'Interaction');
INSERT INTO Type (Type, BaseType, Name) VALUES (52, 00, 'Member of');
INSERT INTO Type (Type, BaseType, Name) VALUES (53, 00, 'Rated as');
INSERT INTO Type (Type, BaseType, Name) VALUES (54, 00, 'Load modeled by');
INSERT INTO Type (Type, BaseType, Name) VALUES (55, 00, 'Shown on');
INSERT INTO Type (Type, BaseType, Name) VALUES (56, 00, 'Made by');
INSERT INTO Type (Type, BaseType, Name) VALUES (57, 00, 'Located with');
INSERT INTO Type (Type, BaseType, Name) VALUES (58, 00, 'Conductor');
INSERT INTO Type (Type, BaseType, Name) VALUES (59, 59, 'DCLineSegment');
INSERT INTO Type (Type, BaseType, Name) VALUES (60, 60, 'Breaker');
INSERT INTO Type (Type, BaseType, Name) VALUES (61, 61, 'Disconnect');
INSERT INTO Type (Type, BaseType, Name) VALUES (62, 62, 'Fuse');
INSERT INTO Type (Type, BaseType, Name) VALUES (63, 63, 'Computer');
INSERT INTO Type (Type, BaseType, Name) VALUES (64, 00, 'Measurement');
INSERT INTO Type (Type, BaseType, Name) VALUES (65, 00, 'Sensor');
INSERT INTO Type (Type, BaseType, Name) VALUES (66, 00, 'Current');
INSERT INTO Type (Type, BaseType, Name) VALUES (67, 00, 'Voltage');
INSERT INTO Type (Type, BaseType, Name) VALUES (68, 00, 'Frequency');
INSERT INTO Type (Type, BaseType, Name) VALUES (69, 00, 'Position');
INSERT INTO Type (Type, BaseType, Name) VALUES (70, 00, 'Impulse');
INSERT INTO Type (Type, BaseType, Name) VALUES (71, 00, 'Contact');
INSERT INTO Type (Type, BaseType, Name) VALUES (72, 00, 'Power');
INSERT INTO Type (Type, BaseType, Name) VALUES (73, 00, 'Measurer');
INSERT INTO Type (Type, BaseType, Name) VALUES (74, 00, 'Telemetered');
INSERT INTO Type (Type, BaseType, Name) VALUES (75, 00, 'Manual');
INSERT INTO Type (Type, BaseType, Name) VALUES (76, 00, 'Calculated');
INSERT INTO Type (Type, BaseType, Name) VALUES (77, 00, 'StateEstimated');
INSERT INTO Type (Type, BaseType, Name) VALUES (78, 00, 'RemoteSystem');
INSERT INTO Type (Type, BaseType, Name) VALUES (79, 00, 'External');
INSERT INTO Type (Type, BaseType, Name) VALUES (80, 00, 'Measurand');
INSERT INTO Type (Type, BaseType, Name) VALUES (81, 00, 'Amps');
INSERT INTO Type (Type, BaseType, Name) VALUES (82, 00, 'kV');
INSERT INTO Type (Type, BaseType, Name) VALUES (83, 00, 'Hertz');
INSERT INTO Type (Type, BaseType, Name) VALUES (84, 00, 'Setting');
INSERT INTO Type (Type, BaseType, Name) VALUES (85, 00, 'Counts');
INSERT INTO Type (Type, BaseType, Name) VALUES (86, 00, 'MW');
INSERT INTO Type (Type, BaseType, Name) VALUES (87, 00, 'MVAr');
INSERT INTO Type (Type, BaseType, Name) VALUES (88, 00, 'MVA');
INSERT INTO Type (Type, BaseType, Name) VALUES (89, 00, 'Status');
INSERT INTO Type (Type, BaseType, Name) VALUES (90, 90, 'Person');
INSERT INTO Type (Type, BaseType, Name) VALUES (91, 21, 'LoadArea');
INSERT INTO Type (Type, BaseType, Name) VALUES (92, 21, 'Loss');
/*
 *      Set up the type heirarchy. The entries in this section must be
 *      ordered by supertype within supertype to ensure that the
```

```
 *      ExtendedType tables gets set up correctly. There should be one
 *       entry for each Type defined above, and that Type's immediate
 *      SuperType must be defined.
 */
INSERT INTO SuperType (SuperType, Type) VALUES (00, 01);

INSERT INTO SuperType (SuperType, Type) VALUES (01, 02);
INSERT INTO SuperType (SuperType, Type) VALUES (01, 14);
INSERT INTO SuperType (SuperType, Type) VALUES (01, 42);
INSERT INTO SuperType (SuperType, Type) VALUES (01, 51);
INSERT INTO SuperType (SuperType, Type) VALUES (01, 64);

INSERT INTO SuperType (SuperType, Type) VALUES (02, 03);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 04);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 05);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 06);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 07);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 08);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 10);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 11);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 12);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 13);
INSERT INTO SuperType (SuperType, Type) VALUES (02, 15);

INSERT INTO SuperType (SuperType, Type) VALUES (14, 16);
INSERT INTO SuperType (SuperType, Type) VALUES (14, 17);
INSERT INTO SuperType (SuperType, Type) VALUES (14, 30);
INSERT INTO SuperType (SuperType, Type) VALUES (14, 63);

INSERT INTO SuperType (SuperType, Type) VALUES (17, 18);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 20);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 21);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 24);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 25);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 26);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 27);
INSERT INTO SuperType (SuperType, Type) VALUES (17, 58);

INSERT INTO SuperType (SuperType, Type) VALUES (21, 40);
INSERT INTO SuperType (SuperType, Type) VALUES (21, 41);
INSERT INTO SuperType (SuperType, Type) VALUES (21, 91);
INSERT INTO SuperType (SuperType, Type) VALUES (21, 92);
INSERT INTO SuperType (SuperType, Type) VALUES (26, 60);
INSERT INTO SuperType (SuperType, Type) VALUES (26, 61);
INSERT INTO SuperType (SuperType, Type) VALUES (26, 62);
INSERT INTO SuperType (SuperType, Type) VALUES (27, 28);
INSERT INTO SuperType (SuperType, Type) VALUES (27, 29);
INSERT INTO SuperType (SuperType, Type) VALUES (58, 19);
INSERT INTO SuperType (SuperType, Type) VALUES (58, 22);
INSERT INTO SuperType (SuperType, Type) VALUES (58, 23);
INSERT INTO SuperType (SuperType, Type) VALUES (58, 59);

INSERT INTO SuperType (SuperType, Type) VALUES (30, 31);
INSERT INTO SuperType (SuperType, Type) VALUES (30, 35);

INSERT INTO SuperType (SuperType, Type) VALUES (31, 32);
INSERT INTO SuperType (SuperType, Type) VALUES (31, 33);
INSERT INTO SuperType (SuperType, Type) VALUES (31, 34);
INSERT INTO SuperType (SuperType, Type) VALUES (35, 36);
INSERT INTO SuperType (SuperType, Type) VALUES (35, 37);
INSERT INTO SuperType (SuperType, Type) VALUES (35, 38);
INSERT INTO SuperType (SuperType, Type) VALUES (35, 39);

INSERT INTO SuperType (SuperType, Type) VALUES (63, 09);

INSERT INTO SuperType (SuperType, Type) VALUES (42, 43);
```

```
INSERT INTO SuperType (SuperType, Type) VALUES (42, 44);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 45);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 46);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 47);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 48);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 49);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 50);
INSERT INTO SuperType (SuperType, Type) VALUES (42, 90);

INSERT INTO SuperType (SuperType, Type) VALUES (51, 52);
INSERT INTO SuperType (SuperType, Type) VALUES (51, 53);
INSERT INTO SuperType (SuperType, Type) VALUES (51, 54);
INSERT INTO SuperType (SuperType, Type) VALUES (51, 55);
INSERT INTO SuperType (SuperType, Type) VALUES (51, 56);
INSERT INTO SuperType (SuperType, Type) VALUES (51, 57);

INSERT INTO SuperType (SuperType, Type) VALUES (64, 65);
INSERT INTO SuperType (SuperType, Type) VALUES (64, 73);
INSERT INTO SuperType (SuperType, Type) VALUES (64, 80);

INSERT INTO SuperType (SuperType, Type) VALUES (65, 66);
INSERT INTO SuperType (SuperType, Type) VALUES (65, 67);
INSERT INTO SuperType (SuperType, Type) VALUES (65, 68);
INSERT INTO SuperType (SuperType, Type) VALUES (65, 69);
INSERT INTO SuperType (SuperType, Type) VALUES (65, 70);
INSERT INTO SuperType (SuperType, Type) VALUES (65, 71);
INSERT INTO SuperType (SuperType, Type) VALUES (65, 72);

INSERT INTO SuperType (SuperType, Type) VALUES (73, 74);
INSERT INTO SuperType (SuperType, Type) VALUES (73, 75);
INSERT INTO SuperType (SuperType, Type) VALUES (73, 76);
INSERT INTO SuperType (SuperType, Type) VALUES (73, 77);
INSERT INTO SuperType (SuperType, Type) VALUES (73, 78);
INSERT INTO SuperType (SuperType, Type) VALUES (73, 79);

INSERT INTO SuperType (SuperType, Type) VALUES (80, 81);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 82);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 83);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 84);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 85);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 86);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 87);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 88);
INSERT INTO SuperType (SuperType, Type) VALUES (80, 89);
```

```
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*****************************************************************************/

/*
 *      This file contains statements to set up all the system defined
 *      nodes and objects.
 */
/*
 *      First, set up the keys. System defined keys range in value from
 *      1 - 10,000; User defined keys range in value from 10,001 to 20,000.
 *      Automatically generated keys (for things added in the general use
 *      of the system) start at 20,001.
 */
INSERT INTO LastKey
    (LastKey
    ,Value
    )
VALUES
    ('Object'
    ,20000
    );
INSERT INTO LastKey
    (LastKey
    ,Value
    )
VALUES
    ('Node'
    ,20000
    );
INSERT INTO LastKey
    (LastKey
    ,Value
    )
VALUES
    ('Type'
    ,20000
    );
INSERT INTO LastKey
    (LastKey
    ,Value
    )
VALUES
    ('Curves'
    ,20000
    );
/*
 *
 *      Objects that are created in this section must have a primary key
 *      that is equal to the base type of the object.
 */
```

```
/*
 *      Set up a "Null" object
 */
INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    ,Description
    )
VALUES
    (0          /* Type$Null */
    ,0          /* Type$Null */
    ,0          /* Type$Null */
    ,0
    ,''
    ,'Null object'
    );

INSERT INTO Location
    (Object
    )
VALUES
    (0          /* Type$Null */
    );
/*
 *      Create the top groupings that everything will belong to
 */
INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    ,Description
    )
VALUES
    (2          /* Type$Organization */
    ,0          /* Type$Null */
    ,2          /* Type$Organization */
    ,0
    ,'Organization'
    ,'Top level organization'
    );

INSERT INTO Grouping
    (SystemVersion
    ,Grouping
    ,Member
    ,Relationship
    )
VALUES
    (0          /* Type$Null */
    ,0          /* Type$Null */
    ,2          /* Type$Organization */
    ,52         /* Type$Member_of */
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    ,Description
```

```
    )
VALUES
    (42          /* Type$Specification */
    ,0           /* Type$Null */
    ,42          /* Type$Specification */
    ,0
    ,'Specification'
    ,'Top level specification'
    );

INSERT INTO Grouping
    (SystemVersion
    ,Grouping
    ,Member
    ,Relationship
    )
VALUES
    (0           /* Type$Null */
    ,0           /* Type$Null */
    ,42          /* Type$Specification */
    ,52          /* Type$Member_of */
    );
/*
 *      Set up a single terminal ground for the entire system.
 */
INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    ,Description
    ,InService
    )
VALUES
    (18              /* Type$Ground */
    ,0               /* Type$Null */
    ,18              /* Type$Ground */
    ,1
    ,'Ground'
    ,'Single terminal ground for entire system'
    ,'1-Jan-1900'
    );

UPDATE  Terminal T
SET     Node = 18            /* Type$Ground */
WHERE   T.Object = 18;       /* Type$Ground */

INSERT INTO Grouping
    (SystemVersion
    ,Grouping
    ,Member
    ,Relationship
    )
VALUES
    (0           /* Type$Null */
    ,42          /* Type$Specification */
    ,18          /* Type$Ground */
    ,52          /* Type$Member_of */
    );
/*
 *      Create the template object for each base type with a key of
 *      BaseType + 5000.
 */
INSERT INTO Object
    (Object
```

```
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
 VALUES
      (02 + 5000  /* Type$Organization */
      ,0          /* Type$Null */
      ,02         /* Type$Organization */
      ,0
      ,'Template'
      );

 INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
 VALUES
      (19 + 5000  /* Type$Busbar */
      ,0          /* Type$Null */
      ,19         /* Type$Busbar */
      ,1
      ,'Template'
      );

 INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
 VALUES
      (20 + 5000  /* Type$Generator */
      ,0          /* Type$Null */
      ,20         /* Type$Generator */
      ,1
      ,'Template'
      );

 INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
 VALUES
      (21 + 5000  /* Type$Consumer */
      ,0          /* Type$Null */
      ,21         /* Type$Consumer */
      ,1
      ,'Template'
      );

 INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
 VALUES
```

```
    (22 + 5000  /* Type$ACLineSegment */
    ,0          /* Type$Null */
    ,22         /* Type$ACLineSegment */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (23 + 5000  /* Type$Jumper */
    ,0          /* Type$Null */
    ,23         /* Type$Jumper */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (24 + 5000  /* Type$Capacitor */
    ,0          /* Type$Null */
    ,24         /* Type$Capacitor */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (25 + 5000  /* Type$Reactor */
    ,0          /* Type$Null */
    ,25         /* Type$Reactor */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (26 + 5000  /* Type$Switch */
    ,0          /* Type$Null */
    ,26         /* Type$Switch */
    ,2
    ,'Template'
    );
```

```
INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (27 + 5000  /* Type$Transformer */
    ,0          /* Type$Null */
    ,27         /* Type$Transformer */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (31 + 5000  /* Type$BreakerSensor */
    ,0          /* Type$Null */
    ,31         /* Type$BreakerSensor */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (35 + 5000  /* Type$Telemetry */
    ,0          /* Type$Null */
    ,35         /* Type$Telemetry */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (43 + 5000  /* Type$TowerType */
    ,0          /* Type$Null */
    ,43         /* Type$TowerType */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
```

```
    ,Name
    )
VALUES
    (44 + 5000  /* Type$ConductorType */
    ,0          /* Type$Null */
    ,44         /* Type$ConductorType */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (45 + 5000  /* Type$RatingFamily */
    ,0          /* Type$Null */
    ,45         /* Type$RatingFamily */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (46 + 5000  /* Type$LoadFamily */
    ,0          /* Type$Null */
    ,46         /* Type$LoadFamily */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (47 + 5000  /* Type$Drawing */
    ,0          /* Type$Null */
    ,47         /* Type$Drawing */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (48 + 5000  /* Type$Manufacturer */
    ,0          /* Type$Null */
    ,48         /* Type$Manufacturer */
```

```
      ,0
      ,'Template'
      );

  INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
  VALUES
      (49 + 5000  /* Type$Season */
      ,0          /* Type$Null */
      ,49         /* Type$Season */
      ,0
      ,'Template'
      );

  INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
  VALUES
      (50 + 5000  /* Type$DayType */
      ,0          /* Type$Null */
      ,50         /* Type$DayType */
      ,0
      ,'Template'
      );

  INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
  VALUES
      (59 + 5000  /* Type$DCLineSegment */
      ,0          /* Type$Null */
      ,59         /* Type$DCLineSegment */
      ,2
      ,'Template'
      );

  INSERT INTO Object
      (Object
      ,SystemVersion
      ,Type
      ,Terminals
      ,Name
      )
  VALUES
      (60 + 5000  /* Type$Breaker */
      ,0          /* Type$Null */
      ,60         /* Type$Breaker */
      ,2
      ,'Template'
      );

  INSERT INTO Object
      (Object
```

```
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (61 + 5000  /* Type$Disconnect */
    ,0          /* Type$Null */
    ,61         /* Type$Disconnect */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (62 + 5000  /* Type$Fuse */
    ,0          /* Type$Null */
    ,62         /* Type$Fuse */
    ,2
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (63 + 5000  /* Type$Computer */
    ,0          /* Type$Null */
    ,63         /* Type$Computer */
    ,0
    ,'Template'
    );

INSERT INTO Object
    (Object
    ,SystemVersion
    ,Type
    ,Terminals
    ,Name
    )
VALUES
    (90 + 5000  /* Type$Person */
    ,0          /* Type$Null */
    ,90         /* Type$Person */
    ,0
    ,'Template'
    );
```

```
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*****************************************************************************/

/*
 *      Parameters relating to the system being modelled are defined here.
 */
INSERT INTO SystemParameters
    (Frequency
    ,MVABase
    ,KVReference
    ,LengthRatio
    ,GroundResistivity
    ,Temperature
    )
VALUES
    (60
    ,100
    ,1
    ,1000
    ,100
    ,'C'
    );
```

```
/*
 *  The following statements define the problem descriptions that are
 *  recognised in the Power System Data Model
 */
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_001', 'E', 'In Service must precede Out of Service');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_002', 'F', 'There is equipment at this voltage');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_003', 'F', 'This device has no more terminals');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_004', 'F', 'Group object does not exist');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_005', 'F', 'Member object does not exist');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_006', 'F', 'Delete not permitted');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_007', 'F', 'Base type of an object may not be changed');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_008', 'F', 'Please select a terminal to connect to');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_009', 'F', 'Please select a terminal to be connected');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_010', 'F', 'Please select a terminal to remove');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_011', 'F', 'There is already a relationship with this objec
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_012', 'F', 'Objects of this type may not be created');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_013', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_014', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_015', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_016', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_017', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_018', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_019', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Object_020', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
```

```
    VALUES ('Capacitor_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Capacitor_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_001', 'W', 'X/R ratio is low');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Conductor_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Consumer_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
```

```
    VALUES ('Generator_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Generator_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Reactor_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Switch_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_001', 'W', 'Nominal kV is out of range of the taps');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_002', 'W', 'Step Size is greater than 10%');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_003', 'E', 'Load tap changer must be "Yes" or "No"');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_004', 'E', 'Low Step must be <= High Step');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_005', 'E', 'Neutral Step must be >= low step');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_006', 'E', 'Neutral step must be <= high step');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_007', 'E', 'Step size must be non-zero');
INSERT INTO Problem (Problem, Severity, Description)
```

```
    VALUES ('Transformer_008', 'F', 'Windings must belong to transformers' ;
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_009', 'E', 'Tap Setting winding does not exist');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_010', 'E', 'Tap Setting tap step is out of range');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_011', 'E', 'Tap Setting windings 1 and 2 must be specif
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_012', 'E', 'Tap Setting windings may be used once only'
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_013', 'E', 'Rated MVA is not specified for any winding'
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_014', 'E', 'Tap Setting impedance is not in the expecte
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_015', 'F', 'Winding is referenced by a Tap Setting');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_016', 'F', 'There are Tap Settings defined');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_017', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_018', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_019', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Transformer_020', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Telemetry_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('ConductorType_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
```

```
    VALUES ('TowerType_001', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_002', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_003', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_004', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_005', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_006', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_007', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('TowerType_010', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_001', 'F', 'Type is in use as a super-type');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_002', 'F', 'There are objects of this type');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_003', 'F', 'Type is system defined and cannot be deleted');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_004', 'F', 'Sub-type does not exist');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_005', 'F', 'Super-type does not exist');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_006', 'F', 'No editor defined for this type of object');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_007', 'F', 'A type of that name already exists');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_008', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_009', '', '');
INSERT INTO Problem (Problem, Severity, Description)
    VALUES ('Type_010', '', '');
```

```
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*****************************************************************************/

DROP PROCEDURE kVLevel$Propagate;
CREATE PROCEDURE kVLevel$Propagate
=
    DECLARE
        i                   INTEGER NOT NULL;
        Loop                INTEGER NOT NULL;
        MaxIterations       INTEGER NOT NULL;
    BEGIN
        DELETE FROM TEMP$TerminalList;
        DELETE FROM TEMP$ObjectList;
        DELETE FROM TEMP$AuditTrail;
/*
 *      Build a list of all the transformer terminals to use as a start point,
 *      and record the fact that they have been processed.
 */
        INSERT INTO TEMP$TerminalList
        SELECT  *
        FROM    Terminal
        WHERE   BaseType = 27;          /* Type$Transformer */

        INSERT INTO TEMP$AuditTrail
        SELECT  Object
        FROM    TEMP$TerminalList;
/*
 *      Loop, looking for new objects, and set their terminal kV levels up
 *      when they are found
 */
        Loop = 1;
        MaxIterations = 40;

        WHILE Loop <= MaxIterations DO
            message loop 'Loops';
            SELECT :i = count(*) from temp$terminalList;
            message i 'Terminals';

/*
 *      Get a list of all the objects connected to the terminals in the
 *      terminal list, propagating the voltage from the terminal list. Force
 *      the voltage propagated to be that of the highest voltage terminal
 *      (in case some are grounded). Note that transformers have already
 *      been dealt with.
 */
            DELETE FROM TEMP$ObjectList;
            INSERT INTO TEMP$ObjectList
                (Object
                ,kVLevel
                )
```

```
            SELECT
                T.Object,
                MAX(TL.kVLevel)
            FROM    Terminal T,
                    TEMP$TerminalList TL
            WHERE   TL.Node = T.Node AND            /* same node */
                    TL.Object != T.Object           /* different object */
            GROUP BY T.Object;
            message iirowcount 'Objects';
/*
 *      Discard any that have already been visited, set the voltage levels
 *      for all the terminals of those that remain, and add them to the
 *      audit trail
 */
            DELETE FROM TEMP$ObjectList OL
            WHERE   OL.Object = (SELECT Object FROM TEMP$AuditTrail);
            message iirowcount 'Revisited';

            UPDATE  Terminal T
            FROM    TEMP$ObjectList OL
            SET     kVLevel = OL.kVLevel
            WHERE   T.Object = OL.Object AND        /* object in object list */
                    T.Node >= 10000;                /* not a system node */
            message iirowcount 'Updated';

            INSERT INTO TEMP$AuditTrail
            SELECT  Object
            FROM    TEMP$ObjectList;
            message iirowcount 'Audited';
/*
 *      Find all the other terminals for these objects
 */
            DELETE FROM TEMP$TerminalList;
            INSERT INTO TEMP$TerminalList
            SELECT  T.*
            FROM    Terminal T,
                    TEMP$ObjectList OL
            WHERE   OL.Object = T.Object AND        /* same object */
                    T.Node >= 10000;                /* not a system node */

            IF IIRowCount = 0 THEN
                ENDLOOP;
            ENDIF;

            Loop = Loop + 1;
        ENDWHILE;
/*
create table objectlist as
    select  object
    from    object
    where   basetype != 27 and
            terminals > 1;

select  ol.object
from    objectlist ol,
        terminal t1,
        terminal t2
where   ol.object = TEMP$objectlist.object and
        ol.object = t2.object and
        t1.terminal != t2.terminal and
        t1.node >= 10000 and
        t2.node >= 10000 and
        t1.kvlevel != t2.kvlevel;
*/
    END;
```

```
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*****************************************************************************/

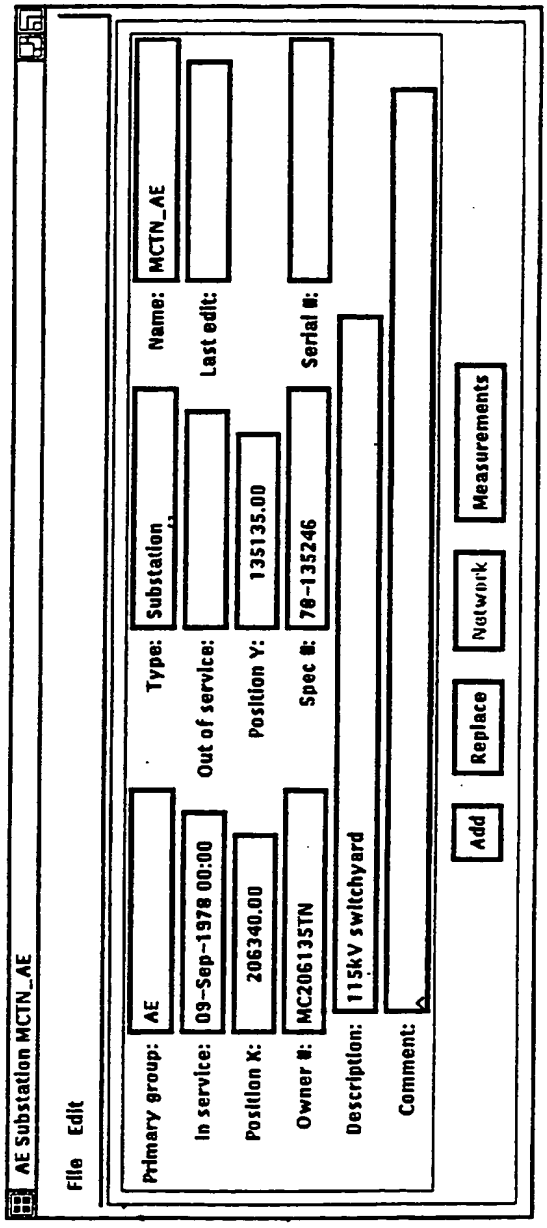
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Waxwing');
UPDATE ConductorType SET
    Resistance=0.238, Radius=0.008, GMR=0.006, Ampacity=440.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Partridge');
UPDATE ConductorType SET
    Resistance=0.236, Radius=0.008, GMR=0.007, Ampacity=440.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Merlin');
UPDATE ConductorType SET
    Resistance=0.189, Radius=0.009, GMR=0.141, Ampacity=500.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Linnet');
UPDATE ConductorType SET
    Resistance=0.187, Radius=0.009, GMR=0.137, Ampacity=510.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Ibis');
UPDATE ConductorType SET
    Resistance=0.159, Radius=0.010, GMR=0.134, Ampacity=570.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Pelican');
UPDATE ConductorType SET
    Resistance=0.133, Radius=0.010, GMR=0.134, Ampacity=625.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Flicker');
UPDATE ConductorType SET
    Resistance=0.133, Radius=0.011, GMR=0.132, Ampacity=635.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Hawk');
UPDATE ConductorType SET
    Resistance=0.132, Radius=0.011, GMR=0.131, Ampacity=640.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Hen');
UPDATE ConductorType SET
    Resistance=0.131, Radius=0.011, GMR=0.129, Ampacity=645.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Osprey');
```

```
UPDATE ConductorType SET
    Resistance=0.115, Radius=0.011, GMR=0.132, Ampacity=690.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Parakeet');
UPDATE ConductorType SET
    Resistance=0.114, Radius=0.012, GMR=0.129, Ampacity=700.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Dove');
UPDATE ConductorType SET
    Resistance=0.113, Radius=0.012, GMR=0.128, Ampacity=710.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Rook');
UPDATE ConductorType SET
    Resistance=0.100, Radius=0.012, GMR=0.126, Ampacity=765.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 44, 'Grosbeak');
UPDATE ConductorType SET
    Resistance=0.099, Radius=0.013, GMR=0.126, Ampacity=775.000
    WHERE   Object = (Select value from lastkey where lastkey='Object');

INSERT INTO Grouping (SystemVersion, Grouping, GroupingType, Member, MemberType,
    SELECT 0, 42, 42, Object, 44, 52
    FROM Object where Type=44 AND Object != 44;
```

```
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 43, 'BPA 500');
Update TowerType SET
a1_offset=-6.707, a1_height=21.951,
b1_offset=0.000, b1_height=31.402,
c1_offset=6.707, c1_height=21.951,
g1_offset=-3.811, g1_height=38.567,
a2_offset=0.000, a2_height=0.000,
b2_offset=0.000, b2_height=0.000,
c2_offset=0.000, c2_height=0.000,
g2_offset=3.811, g2_height=38.567
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 43, 'TVA 500');
Update TowerType SET
a1_offset=-12.195, a1_height=33.232,
b1_offset=0.000, b1_height=33.232,
c1_offset=12.195, c1_height=33.232,
g1_offset=-10.061, g1_height=42.988,
a2_offset=0.000, a2_height=0.000,
b2_offset=0.000, b2_height=0.000,
c2_offset=0.000, c2_height=0.000,
g2_offset=10.061, g2_height=42.988
    WHERE   Object = (Select value from lastkey where lastkey='Object');
INSERT INTO Object (Object, Type, Name)
    VALUES (-1, 43, 'APL 500');
Update TowerType SET
a1_offset=-9.223, a1_height=28.049,
b1_offset=0.000, b1_height=28.049,
c1_offset=9.223, c1_height=28.049,
g1_offset=-6.174, g1_height=37.957,
a2_offset=0.000, a2_height=0.000,
b2_offset=0.000, b2_height=0.000,
c2_offset=0.000, c2_height=0.000,
g2_offset=6.174, g2_height=37.957
    WHERE   Object = (Select value from lastkey where lastkey='Object');

INSERT INTO Grouping (SystemVersion, Grouping, GroupingType, Member, MemberType,
    SELECT 0, 42, 42, Object, 43, 52
    FROM Object where Type=43 AND Object != 43;
```



```
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*****************************************************************************/

INITIALIZE
    (
    Object = INTEGER;                          /* Object being edited */
    OG = ARRAY OF GroupingClass;               /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;            /* Measurements made on it */
    RO = ObjectSummaryClass;                   /* Exchange replacement object
    i = INTEGER;                               /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

On UserEvent 'T.GetAttributes'=
    BEGIN
        ROLLBACK;
    END;

On UserEvent 'T.Update'=
    BEGIN
        COMMIT;
    END;
```

```
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*****************************************************************************/

ON UserEvent 'O.GetAttributes' =
/*
 *      Get the object attributes, then get the type specific attributes
 */
    BEGIN
        REPEATED
        SELECT  :O.Object = O.Object,
                :O.BaseType = O.BaseType,
                :O.Type = O.Type,
                :O.PrimaryGrouping = O.PrimaryGrouping,
                :O.TypeName = O.TypeName,
                :O.PrimaryGroupingName = O.PrimaryGroupingName,
                :O.Name = O.Name,
                :O.Description = O.Description,
                :O.Comment = O.Comment,
                :O.Terminals = O.Terminals,
                :O.InService = O.InService,
                :O.OutService = O.OutService,
                :O.PositionX = O.PositionX,
                :O.PositionY = O.PositionY,
                :O.OwnerNumber = O.OwnerNumber,
                :O.SerialNumber = O.SerialNumber,
                :O.SpecNumber = O.SpecNumber,
                :O.LastChanged = O.LastChanged,
                :O.LastChangedBy = O.LastChangedBy
        FROM    Object O
        WHERE   :Object = O.Object;

        INQUIRE_SQL( :i = ERRORNO );

        IF i != 0 THEN
            ROLLBACK;
            RESUME;
        ENDIF;

        CurFrame.WindowTitle =
            Squeeze (O.PrimaryGroupingName + ' ' + O.TypeName + ' ' + O.Name);
/*
 *      If the object has no terminals, disallow access to the Network button
 */
        IF O.Terminals <= 0 THEN
            FIELD(Network).CurBias = FB_Dimmed;
        ENDIF;
/*
 *      Mark the identifiers as unchanged
 */
        FIELD(O.PrimaryGroupingName).HasDataChanged = FALSE;
```

```
        FIELD(O.TypeName).HasDataChanged = FALSE;
        FIELD(O.Name).HasDataChanged = FALSE;
/*
 *      Get the groupings and measurements also
 */
        OG.Clear();
        i = 1;
        REPEATED
        SELECT  :OG[i].SystemVersion = G.SystemVersion,
                :OG[i].Grouping = G.Grouping,
                :OG[i].GroupingType = G.GroupingType,
                :OG[i].Relationship = G.Relationship,
                :OG[i].Reference = G.Reference
        FROM    Grouping G
        WHERE   :Object = G.Member
        BEGIN
            i = i + 1;
        END;

        OM.Clear();
        i = 1;
        REPEATED
        SELECT  :OM[i].MeasurandType = M.MeasurandType,
                :OM[i].Terminal1 = M.Terminal1,
                :OM[i].Terminal2 = M.Terminal2,
                :OM[i].SensorType = M.SensorType,
                :OM[i].SensorMinimum = M.SensorMinimum,
                :OM[i].SensorMaximum = M.SensorMaximum,
                :OM[i].SensorAccuracy = M.SensorAccuracy,
                :OM[i].ReversePolarity = M.ReversePolarity,
                :OM[i].MeasurerType = M.MeasurerType,
                :OM[i].Measurer = M.Measurer,
                :OM[i].Alarm = M.Alarm,
                :OM[i].History = M.History,
                :OM[i].Trigger = M.Trigger,
                :OM[i].EventLog = M.EventLog,
                :OM[i].Input = M.Input,
                :OM[i].Output = M.Output
        FROM    Measurement M
        WHERE   :Object = M.Measurand
        BEGIN
            i = i + 1;
        END;

        CurFrame.SendUserEvent (EventName = 'T.GetAttributes');
END;
```

```
ON Click Menu.File.Add,
ON Click Add,
ON UserEvent 'O.Insert' =
/*
 *      Set up the object, get the key set up by the insert, and
 *      update the object associated with it as part of the same transaction.
 */
    BEGIN
        REPEATED
        INSERT INTO Object
            (Object
            ,Name
            ,Type
            ,TypeName
            ,PrimaryGrouping
            ,PrimaryGroupingName
            ,Terminals
            )
        VALUES
            (-1
            ,:O.Name
            ,:O.Type
            ,:O.TypeName
            ,:O.PrimaryGrouping
            ,:O.PrimaryGroupingName
            ,:O.Terminals
            );

        INQUIRE_SQL( :i = ERRORNO );

        IF i != 0 THEN
            ROLLBACK;
            RESUME;
        ENDIF;

        REPEATED
        SELECT  :O.Object = K.Value
        FROM    LastKey K
        WHERE   K.LastKey = 'Object';

        Object = O.Object;
/*
 *      Mark the identifiers as unchanged to prevent warnings
 *      on the update.
 */
        FIELD(O.PrimaryGroupingName).HasDataChanged = FALSE;
        FIELD(O.TypeName).HasDataChanged = FALSE;
        FIELD(O.Name).HasDataChanged = FALSE;

        CurFrame.SendUserEvent (EventName = 'O.Update');
    END;

ON Click Menu.File.Replace,
ON Click Replace,
ON UserEvent 'O.Update' =
    BEGIN
/*
 *      Check if any of the identifier fields have changed. If so, warn
 *      the user, as this may be a hit on Replace when Add was intended
 */
        IF (FIELD(O.PrimaryGroupingName).HasDataChanged = TRUE OR
            FIELD(O.TypeName).HasDataChanged = TRUE OR
            FIELD(O.Name).HasDataChanged = TRUE) THEN
/****   Replace with message read from Problem ****/
/****   (V2.0 also use defaulting of buttons) ****/
```

```
            IF (CurFrame.ConfirmPopup
                (MessageText = 'You will overwrite an existing object') =
                PU_Cancel) THEN
                ROLLBACK;
                RESUME;
            ENDIF;

        ENDIF;
/*
 *      Update the enterable parts of the object record in the database,
 *      then update the type specific details.
 */
        REPEATED
        UPDATE  Object O
        SET     Type = :O.Type,
                PrimaryGrouping = :O.PrimaryGrouping,
                TypeName = :O.TypeName,
                PrimaryGroupingName = :O.PrimaryGroupingName,
                Name = :O.Name,
                Description = :O.Description,
                Comment = :O.Comment,
                InService = :O.InService,
                OutService = :O.OutService,
                PositionX = :O.PositionX,
                PositionY = :O.PositionY,
                OwnerNumber = :O.OwnerNumber,
                SerialNumber = :O.SerialNumber,
                SpecNumber = :O.SpecNumber,
                LastChanged = Date ('now'),
                LastChangedBy = DBMSInfo ('Username')
        WHERE   :Object = O.Object;
/*
 *      Trash all the groupings in the database and replace them
 */
        REPEATED
        DELETE FROM Grouping
        WHERE   :Object = Member;

        i = 1;
        WHILE i <= OG.LastRow() DO
            REPEATED
            INSERT INTO Grouping
                (SystemVersion
                ,Grouping
                ,GroupingType
                ,Member
                ,MemberType
                ,Relationship
                ,Reference
                )
            VALUES
                (:OG[i].SystemVersion
                ,:OG[i].Grouping
                ,:OG[i].GroupingType
                ,:Object
                ,:O.Type
                ,:OG[i].Relationship
                ,:OG[i].Reference
                );
            i = i + 1;
        ENDWHILE;
/*
 *      Trash all the measurements in the database and replace them
 */
        REPEATED
        DELETE FROM Measurement
```

```
        WHERE   :Object = Measurand;

        i = 1;
        WHILE i <= OM.LastRow() DO
            REPEATED
            INSERT INTO Measurement
                (Measurand
                ,MeasurandType
                ,Terminal1
                ,Terminal2
                ,SensorType
                ,SensorMinimum
                ,SensorMaximum
                ,SensorAccuracy
                ,ReversePolarity
                ,MeasurerType
                ,Measurer
                ,Alarm
                ,History
                ,Trigger
                ,EventLog
                ,Input
                ,Output
                )
            VALUES
                (:Object
                ,:OM[i].MeasurandType
                ,:OM[i].Terminal1
                ,:OM[i].Terminal2
                ,:OM[i].SensorType
                ,:OM[i].SensorMinimum
                ,:OM[i].SensorMaximum
                ,:OM[i].SensorAccuracy
                ,:OM[i].ReversePolarity
                ,:OM[i].MeasurerType
                ,:OM[i].Measurer
                ,:OM[i].Alarm
                ,:OM[i].History
                ,:OM[i].Trigger
                ,:OM[i].EventLog
                ,:OM[i].Input
                ,:OM[i].Output
                );
            i = i + 1;
        ENDWHILE;

        COMMIT;

        CurFrame.SendUserEvent (EventName = 'T.Update');
        CurFrame.SendUserEvent (EventName = 'O.GetAttributes');
    END;
```

```
ON Click Menu.File.Exchange =
    BEGIN
/*
 *      Go and get the piece of equipment to replace this one
 */
        RO = CALLFRAME FindObject
             (SuperType = O.BaseType
             ) WITH
             WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;

        IF RO IS NULL THEN
            ROLLBACK;
            RESUME;
        ENDIF;
/*
 *      Check that the replacement has the same number of terminals as the
 *      current object.
 */
        SELECT  :i = COUNT(*)
        FROM    Object O,
                Object R
        WHERE   :O.Object = O.Object AND
                :RO.Object = R.Object AND
                O.Terminals = R.Terminals;

        IF i = 0 THEN
            MESSAGE 'The replacement has a different number of terminals.';
            ROLLBACK;
            RESUME;
        ENDIF;
/*
 *      Exchange all the terminals, groupings and measurements. Negate
 *      the keys to prevent duplicates during the exchange.
 */
        UPDATE  Terminal T1
        FROM    Terminal T2
        SET     Object =  - T2.Object
        WHERE   (:O.Object = T1.Object AND :RO.Object = T2.Object) OR
                (:RO.Object = T1.Object AND :O.Object = T2.Object);

        UPDATE  Terminal
        SET     Object = - Object
        WHERE   Object < 0;

        UPDATE  Grouping G1
        FROM    Grouping G2
        SET     Member = - G2.Member,
                MemberType = G2.MemberType
        WHERE   (:O.Object = G1.Member AND :RO.Object = G2.Member) OR
                (:RO.Object = G1.Member AND :O.Object = G2.Member);

        UPDATE  Grouping
        SET     Member = - Member
        WHERE   Member < 0;

        UPDATE  Measurement M1
        FROM    Measurement M2
        SET     Measurand = - M2.Measurand
        WHERE   (:O.Object = M1.Measurand AND :RO.Object = M2.Measurand) OR
                (:RO.Object = M1.Measurand AND :O.Object = M2.Measurand);

        UPDATE  Measurement
        SET     Measurand = - Measurand
        WHERE   Measurand < 0;
/*
```

```
*       Now change the primary grouping and name
*/
        UPDATE  Object O1
        FROM    Object O2
        SET     Type = - O2.Type,
                PrimaryGrouping = O2.PrimaryGrouping,
                Name = O2.Name
        WHERE   (:O.Object = O1.Object AND :RO.Object = O2.Object) OR
                (:RO.Object = O1.Object AND :O.Object = O2.Object);

        UPDATE  Object
        SET     Type = - Type
        WHERE   Type < 0;

        COMMIT;
/*
*       Stay with the same network position - so change to the new object
*/
        Object = RO.Object;
        CurFrame.SendUserEvent (EventName = 'O.GetAttributes');
    END;
```

```
ON Click Menu.Edit.Type,
ON Entry O.TypeName =
/*
 *      Show the user the types that this object can belong to, so
 *      that one may be selected
 */
    BEGIN
        i = O.Type;
        CALLFRAME SetType (Object = O);

        IF i != O.Type THEN
            FIELD(O.TypeName).HasDataChanged = TRUE;
        ENDIF;

        RESUME;          /* Keep input focus out of this field  */
    END;

ON Click Menu.Edit.Groupings,
ON Entry O.PrimaryGroupingName =
/*
 *      Show the user the groups that this object belongs to, so
 *      that they can be edited
 */
    BEGIN
        i = O.PrimaryGrouping;
        CALLFRAME SetGrouping (Object = O, OG = OG);

        IF i != O.PrimaryGrouping THEN
            FIELD(O.PrimaryGroupingName).HasDataChanged = TRUE;
        ENDIF;

        RESUME;          /* Keep input focus out of this field  */
    END;
```

```
ON Click Menu.Edit.Network_1,
ON Click Network =

    BEGIN
        GlobalFrame[Frame$ConnectivityEditor].Frame.SendUserEvent
            (EventName = 'LoadObject_D1', MessageInteger = Object);
    END;

ON Click Menu.Edit.Network_2,
ON Details Network =

    BEGIN
        GlobalFrame[Frame$ConnectivityEditor].Frame.SendUserEvent
            (EventName = 'LoadObject_D2', MessageInteger = Object);
    END;

ON Click Menu.Edit.Measurements,
ON Click Measurements =
/*
 *      Show the user the measurements made on this object, so
 *      that they can be edited
 */
    BEGIN
        CALLFRAME SetMeasurement (Object = O, OM = OM);
    END;
```

```
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*****************************************************************************/

/*
**      Application:  PowerSystemModel
**      Procedure:    ObjectEditor
*/
PROCEDURE ObjectEditor
    (
    OS = ObjectSummaryClass;                    /* Object summary */
    FrameName = VARCHAR(20) NOT NULL;           /* Editor frame name */
    FrameTitle = VARCHAR(80) NOT NULL;          /* Editor frame title */
    )=
    BEGIN
        REPEATED
        SELECT  :FrameName = BT.EditorName
        FROM    BaseType BT
        WHERE   :OS.BaseType = BT.Type;

        IF FrameName = '' THEN
            INSERT INTO GrassCatcher (Object, Text, Problem)
                VALUES (0, OS.TypeName, 'Type_006');
            ROLLBACK;
            RETURN;
        ENDIF;

        FrameTitle = OS.PrimaryGroupingName + ' ' + OS.TypeName + ' ' + OS.Name;
        FrameTitle = Squeeze (FrameTitle);
        OPENFRAME :FrameName (Object = OS.Object) WITH
            WindowTitle = FrameTitle,
            ParentFrame = NULL;          /* Should be parent frame of procedure
        RETURN;
    END;
```

```
/*
**      Application:  PowerSystemModel
**      Procedure:    LoadTypeList
*/
PROCEDURE LoadTypeList
    (
    EF = EnumField;                          /* Enumerated field to be set up
    StartType = INTEGER;                     /* Type to start with */
    Type = TypeClass;                        /* Scratch type */
    CList = ChoiceList;                      /* Scratch choice list entry */
    i = INTEGER NOT NULL;                    /* Scratch integer */
    )=
    BEGIN
/*
 *      Set up the values in the choice list
 */
        CList = EF.ValueList;
        CList.ChoiceItems.Clear();
        CList.ChoiceItems[1].EnumValue = 0;
        CList.ChoiceItems[1].EnumText = '';
        i = 2;

        REPEATED
        SELECT  :Type.Type = T.Type,
                :Type.Name = T.Name
        FROM    Type T,
                ExtendedType ET
        WHERE   :StartType = ET.SuperType AND
                ET.Type = T.Type
        ORDER BY Name
        BEGIN
            CList.ChoiceItems[i].EnumValue = Type.Type;
            CList.ChoiceItems[i].EnumText = Type.Name;
            i = i + 1;
        END;
/*
 *      Ensure it is updated on the screen
 */
        EF.UpdChoiceList();
    END;
```

```
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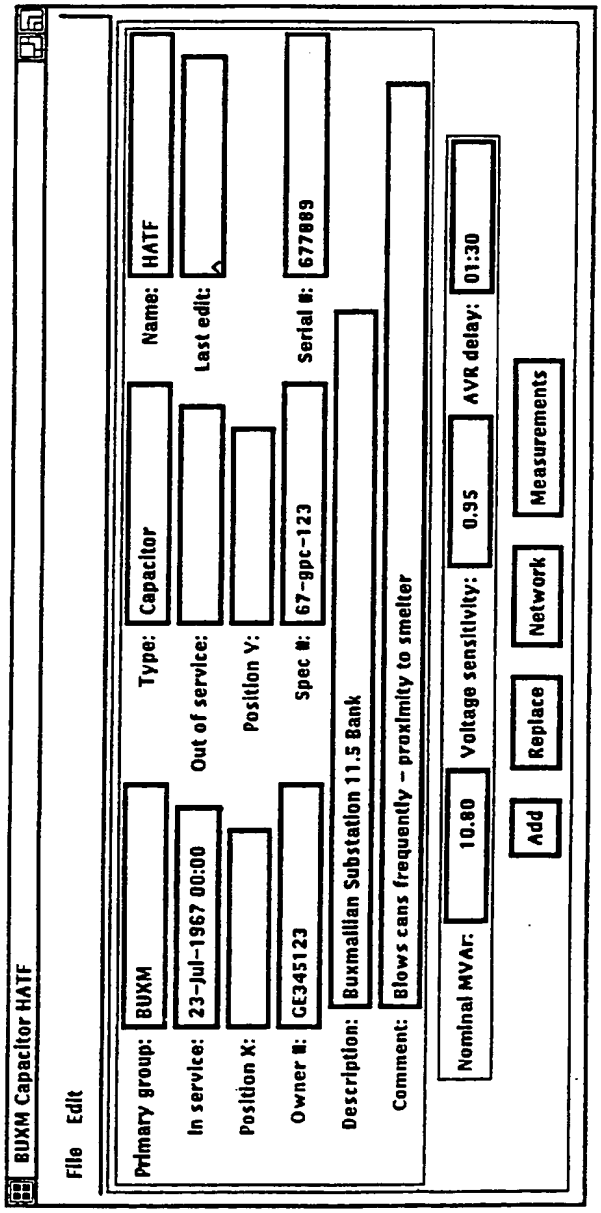
 *****************************************************************************/

/*
**      Application:      PowerSystemModel
**      Frame:            Menu.File.CloseButton
*/
ON Click Menu.File.CloseButton =

    BEGIN
        RETURN;
    END;
```



```
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*****************************************************************************/

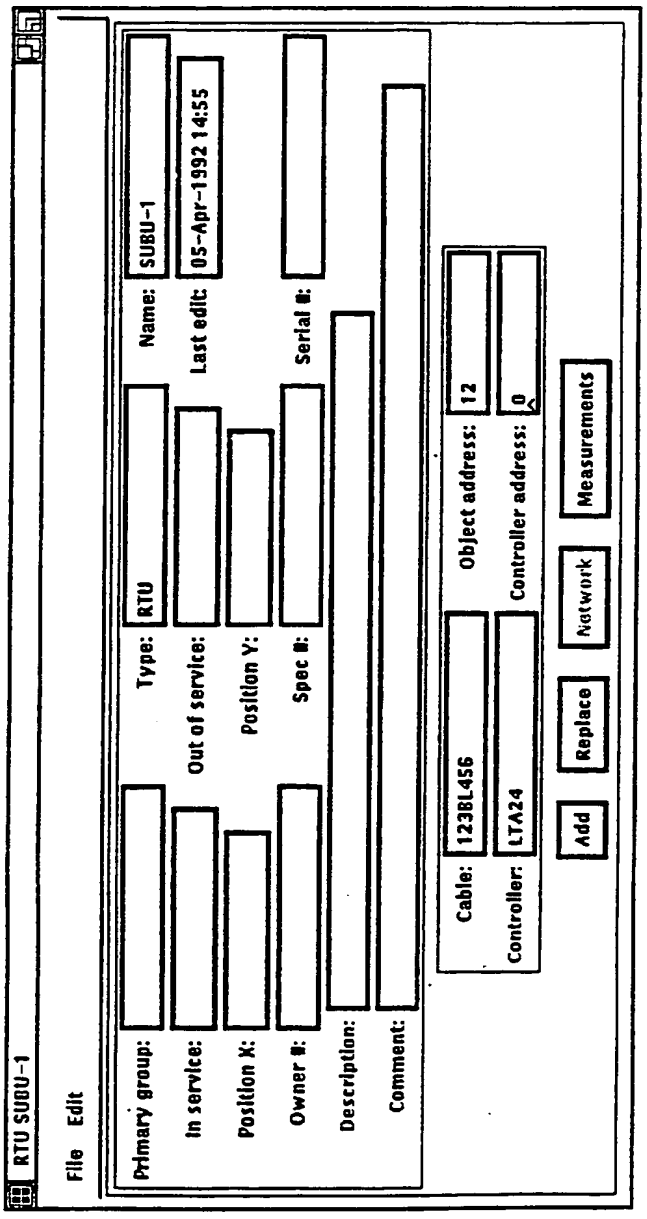
INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :C.Object = C.Object,
                :C.NominalMVAr = C.NominalMVAr,
                :C.VoltSensitivity = C.VoltSensitivity,
                :C.AVRDelay = C.AVRDelay
        FROM    Capacitor C
        WHERE   :Object = C.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Capacitor C
        SET     NominalMVAr = :C.NominalMVAr,
                VoltSensitivity = :C.VoltSensitivity,
                AVRDelay = :C.AVRDelay
        WHERE   :Object = C.Object;

        COMMIT;
    END;
```



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*****************************************************************************/

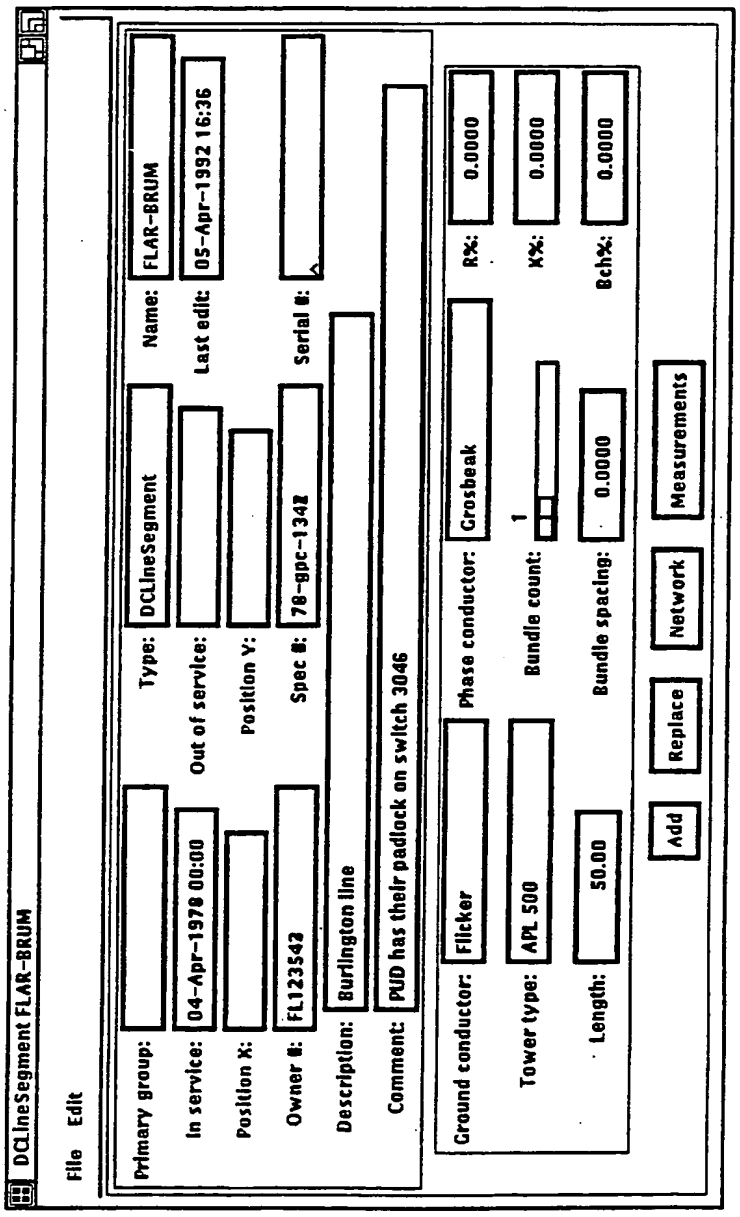
INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :C.Object = C.Object,
                :C.ObjectAddress = C.ObjectAddress,
                :C.Controller = C.Controller,
                :C.ControllerAddress = C.ControllerAddress,
                :C.Cable = C.Cable
        FROM    Computer C
        WHERE   :Object = C.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Computer C
        SET     ObjectAddress = :C.ObjectAddress,
                Controller = :C.Controller,
                ControllerAddress = :C.ControllerAddress,
                Cable = :C.Cable
        WHERE   :Object = C.Object;

        COMMIT;
    END;
```



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*****************************************************************************/

INITIALIZE
    (
    Object = INTEGER;                          /* Object being edited */
    OG = ARRAY OF GroupingClass;               /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;            /* Measurements made on it */
    RO = ObjectSummaryClass;                   /* Exchange replacement object
    i = INTEGER;                               /* Scratch integer */

    N = INTEGER NOT NULL;                      /* Count */
    A = FLOAT NOT NULL;                        /* Scratch */
    B = FLOAT NOT NULL;                        /* Scratch */
    kV = FLOAT;                                /* Voltage */
    Dab = FLOAT;                               /* GMD a phase to b phase */
    Dbc = FLOAT;                               /* GMD b phase to c phase */
    Dca = FLOAT;                               /* GMD c phase to a phase */
    Deq = FLOAT;                               /* Equivalent GMD */
    GMReq = FLOAT;                             /* Equivalent GMR for bundle
    Radiuseq = FLOAT;                          /* Equivalent radius for bundle
    R = FLOAT;                                 /* Series resistance */
    X = FLOAT;                                 /* Series inductive reactance
    Bch = FLOAT;                               /* Shunt susceptance */
    ZBase = FLOAT;                             /* Impedance base */
    Omega = FLOAT;                             /* Angular frequency */
    Pi = FLOAT NOT NULL;                       /* Pi */
    )=
    BEGIN
        Pi = 3.141592654;
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;
```

```
ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :S.Object = S.Object,
                :S.R = S.R,
                :S.X = S.X,
                :S.Bch = S.Bch,
                :S.Length = S.Length,
                :S.TowerType = S.TowerType,
                :S.GroundConductorType = S.GroundConductorType,
                :S.PhaseConductorType = S.PhaseConductorType,
                :S.PhaseConductorCount = S.PhaseConductorCount,
                :S.PhaseConductorSpacing = S.PhaseConductorSpacing
        FROM    Conductor S
        WHERE   :Object = S.Object;

        REPEATED
        SELECT  :kV = T.KVLevel
        FROM    Terminal T
        WHERE   :S.Object = T.Object;

        CurFrame.SendUserEvent (EventName = 'GetTowerType');
        CurFrame.SendUserEvent (EventName = 'GetGroundConductorType');
        CurFrame.SendUserEvent (EventName = 'GetPhaseConductorType');

        ROLLBACK;
    END;

On UserEvent 'GetTowerType'=
    BEGIN
        REPEATED
        SELECT  :S.TT.Object = TT.Object,
                :S.TT.Name = TTO.Name,
                :S.TT.A1_Offset = TT.A1_Offset,
                :S.TT.A1_Height = TT.A1_Height,
                :S.TT.B1_Offset = TT.B1_Offset,
                :S.TT.B1_Height = TT.B1_Height,
                :S.TT.C1_Offset = TT.C1_Offset,
                :S.TT.C1_Height = TT.C1_Height,
                :S.TT.G1_Offset = TT.G1_Offset,
                :S.TT.G1_Height = TT.G1_Height,
                :S.TT.A2_Offset = TT.A2_Offset,
                :S.TT.A2_Height = TT.A2_Height,
                :S.TT.B2_Offset = TT.B2_Offset,
                :S.TT.B2_Height = TT.B2_Height,
                :S.TT.C2_Offset = TT.C2_Offset,
                :S.TT.C2_Height = TT.C2_Height,
                :S.TT.G2_Offset = TT.G2_Offset,
                :S.TT.G2_Height = TT.G2_Height
        FROM    TowerType TT,
                Object TTO
        WHERE   :S.TowerType = TT.Object AND
                :S.TowerType = TTO.Object;

        ROLLBACK;
    END;

On UserEvent 'GetGroundConductorType'=
    BEGIN
        REPEATED
        SELECT  :S.GCT.Object = GCT.Object,
                :S.GCT.Name = GCTO.Name,
                :S.GCT.Resistance = GCT.Resistance,
                :S.GCT.Radius = GCT.Radius,
                :S.GCT.GMR = GCT.GMR,
```

```
                :S.GCT.Ampacity = GCT.Ampacity
        FROM    ConductorType GCT,
                Object GCTO
        WHERE   :S.GroundConductorType = GCT.Object AND
                :S.GroundConductorType = GCTO.Object;

        ROLLBACK;
    END;

On UserEvent 'GetPhaseConductorType'=
    BEGIN
        REPEATED
        SELECT  :S.PCT.Object = PCT.Object,
                :S.PCT.Name = PCTO.Name,
                :S.PCT.Resistance = PCT.Resistance,
                :S.PCT.Radius = PCT.Radius,
                :S.PCT.GMR = PCT.GMR,
                :S.PCT.Ampacity = PCT.Ampacity
        FROM    ConductorType PCT,
                Object PCTO
        WHERE   :S.PhaseConductorType = PCT.Object AND
                :S.PhaseConductorType = PCTO.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Conductor S
        SET     R = :S.R,
                X = :S.X,
                Bch = :S.Bch,
                Length = :S.Length,
                TowerType = :S.TowerType,
                GroundConductorType = :S.GroundConductorType,
                PhaseConductorType = :S.PhaseConductorType,
                PhaseConductorCount = :S.PhaseConductorCount,
                PhaseConductorSpacing = :S.PhaseConductorSpacing
        WHERE   :Object = S.Object;

        COMMIT;
    END;

ON Entry S.TT.Name =
/*
 *      Show the user the list of possible tower types
 */
    BEGIN
        i = CALLFRAME SetObject (Type = Type$TowerType
                                ,DefaultObject = S.TowerType);

        IF i IS NOT NULL THEN
            S.TowerType = i;
            CurFrame.SendUserEvent (EventName = 'GetTowerType');
            CurFrame.SendUserEvent (EventName = 'Recalculate');
        ENDIF;

        RESUME;          /* Keep input focus out of this field  */
    END;

ON Entry S.GCT.Name =
/*
 *      Show the user the list of possible conductor types
 */
    BEGIN
```

```
        i = CALLFRAME SetObject (Type = TypeSConductorType
                                ,DefaultObject = S.GroundConductorType);

        IF i IS NOT NULL THEN
            S.GroundConductorType = i;
            CurFrame.SendUserEvent (EventName = 'GetGroundConductorType');
            CurFrame.SendUserEvent (EventName = 'Recalculate');
        ENDIF;

        RESUME;          /* Keep input focus out of this field  */
    END;

ON Entry S.PCT.Name =
/*
 *      Show the user the list of possible conductor types
 */
    BEGIN
        i = CALLFRAME SetObject (Type = TypeSConductorType
                                ,DefaultObject = S.PhaseConductorType);

        IF i IS NOT NULL THEN
            S.PhaseConductorType = i;
            CurFrame.SendUserEvent (EventName = 'GetPhaseConductorType');
            CurFrame.SendUserEvent (EventName = 'Recalculate');
        ENDIF;

        RESUME;          /* Keep input focus out of this field  */
    END;
```

```
ON UserEvent 'Recalculate',
ON ChildSetValue S =
    BEGIN
        IF  S.TowerType != 0 AND
            S.PhaseConductorType != 0 AND
            S.Length IS NOT NULL THEN
/*
**        Equivalent GMR and radius for bundles (from Dommel eq. 56)
*/
            N = S.PhaseConductorCount;
            IF S.PhaseConductorSpacing > (2.0 * S.PCT.Radius) THEN
                A = S.PhaseConductorSpacing / (2.0 * SIN (PI / N));
            ELSE
                A = (2.0 * S.PCT.Radius) / (2.0 * SIN (PI / N));
            ENDIF;

            GMReq = (N * S.PCT.GMR * (A ** (N - 1))) ** (1.0 / N);
            Radiuseq = (N * S.PCT.Radius * (A ** (N - 1))) ** (1.0 / N);
/*
**        Get the GMD for each phase pair and the equivalent GMD
**        (from Stevenson eq. 3.52)
*/
            A = ABS (S.TT.A1_Height - S.TT.B1_Height) ** 2;
            B = ABS (S.TT.A1_Offset - S.TT.B1_Offset) ** 2;
            Dab = (A + B) ** 0.5;

            IF S.TT.B2_Height != 0 THEN
                A = ABS (S.TT.A1_Height - S.TT.B2_Height) ** 2;
                B = ABS (S.TT.A1_Offset - S.TT.B2_Offset) ** 2;
                Dab = (Dab * ((A + B) ** 0.5)) ** 0.5;
            ENDIF;

            A = ABS (S.TT.B1_Height - S.TT.C1_Height) ** 2;
            B = ABS (S.TT.B1_Offset - S.TT.C1_Offset) ** 2;
            Dbc = (A + B) ** 0.5;

            IF S.TT.C2_Height != 0 THEN
                A = ABS (S.TT.B1_Height - S.TT.C2_Height) ** 2;
                B = ABS (S.TT.B1_Offset - S.TT.C2_Offset) ** 2;
                Dbc = (Dbc * ((A + B) ** 0.5)) ** 0.5;
            ENDIF;

            A = ABS (S.TT.C1_Height - S.TT.A1_Height) ** 2;
            B = ABS (S.TT.C1_Offset - S.TT.A1_Offset) ** 2;
            Dca = (A + B) ** 0.5;

            IF S.TT.A2_Height != 0 THEN
                A = ABS (S.TT.C1_Height - S.TT.A2_Height) ** 2;
                B = ABS (S.TT.C1_Offset - S.TT.A2_Offset) ** 2;
                Dca = (Dca * ((A + B) ** 0.5)) ** 0.5;
            ENDIF;

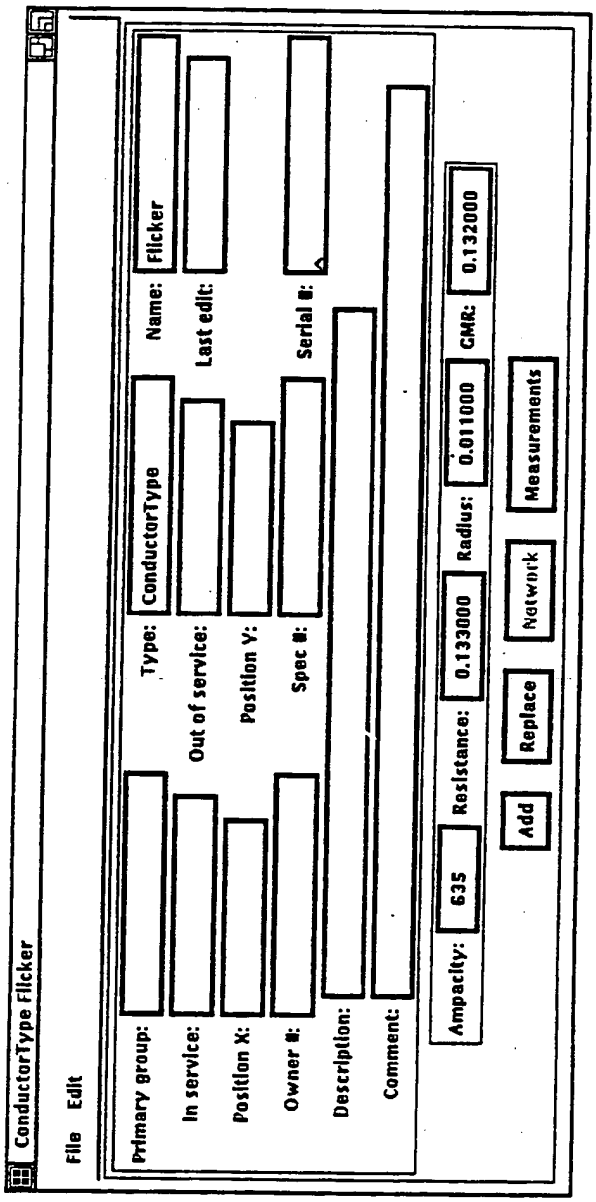
            Deq = (Dab * Dbc * Dca) ** (1.0 / 3.0);
/*
**        Get the series reactance value in Ohms / Km (from Dommel eq. 54)
**        and convert it to per cent for the segment length.
*/
            Omega = 2.0 * Pi * SP.Frequency;
            ZBase = (kV ** 2) / SP.MVABase;

            X = Omega * (2.0 * (10.0**-4)) * LOG (Deq / GMReq);
            S.X = X / ZBase * S.Length * 100.0;
/*
**      Get the shunt susceptance in Siemens / Km (from Dommel eq. 58)
**      and convert it to per cent for the segment length.
```

```
*/
            Bch = Omega * (10.0**-6) / (18.0 * LOG (Deq / Radiuseq));
            S.Bch = Bch * ZBase * S.Length * 100.0;
/*
**      Get the resistance for the bundle in Ohms / Unit length
**      and convert it to per cent for the segment length.
**      Add 2% for spiralling.
*/
            S.R = S.PCT.Resistance / S.PhaseConductorCount;
            S.R = S.R / ZBase * S.Length * 100.0;
            S.R = S.R * 1.02;

        ENDIF;

    END;
```



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*****************************************************************************/

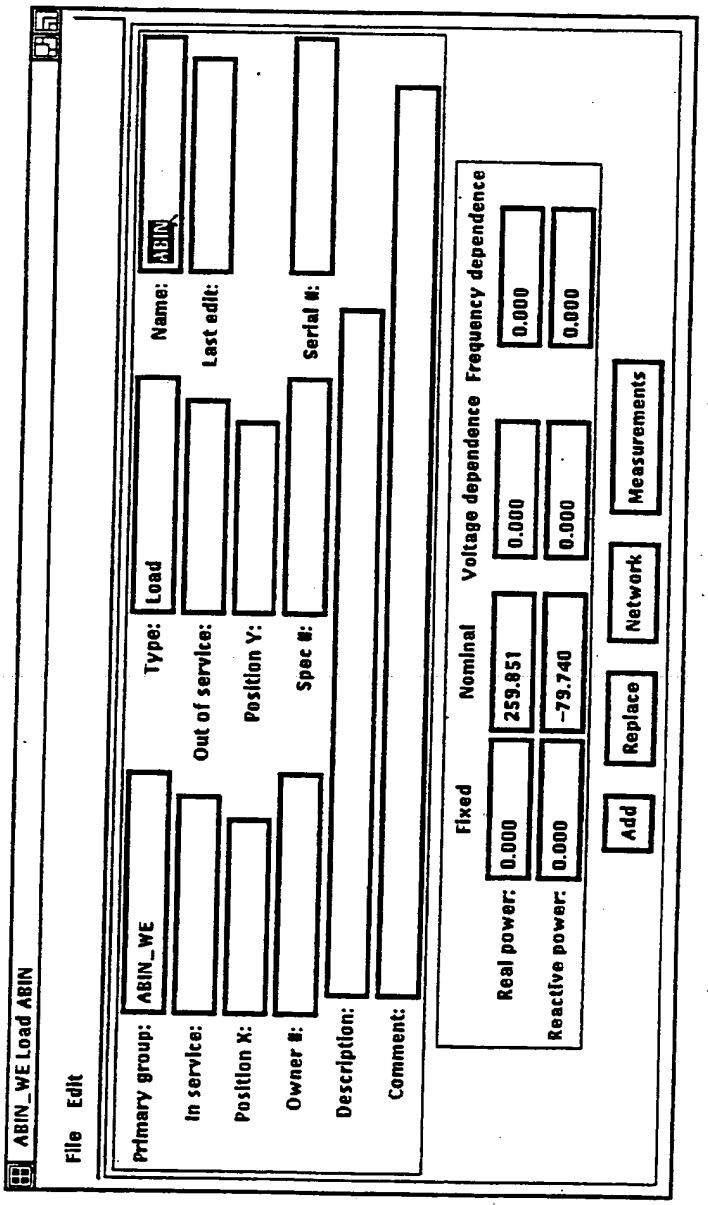
/*
**      Application:      PowerSystemModel
**      Frame:            ConductorType
*/
INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
/*
**      Get the conductor details
*/
        SELECT  :C.Ampacity = C.Ampacity,
                :C.Resistance = C.Resistance,
                :C.Radius = C.Radius,
                :C.GMR = C.GMR
        FROM    ConductorType C
        WHERE   :Object = C.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        UPDATE  ConductorType C
        SET     Ampacity = :C.Ampacity,
                Resistance = :C.Resistance,
                Radius = :C.Radius,
                GMR = :C.GMR
        WHERE   :Object = C.Object;

        COMMIT;
    END;
```



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 *****************************************************************************/

INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object
    OS = ObjectSummaryClass;                            /*** Temp ***/
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :C.Object = C.Object,
                :C.Pfixed = C.Pfixed,
                :C.Qfixed = C.Qfixed,
                :C.Pnom = C.Pnom,
                :C.Qnom = C.Qnom,
                :C.PowerFactor = C.PowerFactor,
                :C.PfixedPct = C.PfixedPct,
                :C.QfixedPct = C.QfixedPct,
                :C.PnomPct = C.PnomPct,
                :C.QnomPct = C.QnomPct,
                :C.PVexp = C.PVexp,
                :C.QVexp = C.QVexp,
                :C.PFexp = C.PFexp,
                :C.QFexp = C.QFexp
        FROM    Consumer C
        WHERE   :Object = C.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Consumer C
        SET     Type = :O.Type,                 /*** Temporary - to speed rules ***/
                Pfixed = :C.Pfixed,
                Qfixed = :C.Qfixed,
                Pnom = :C.Pnom,
                Qnom = :C.Qnom,
                PowerFactor = :C.PowerFactor,
                PVexp = :C.PVexp,
```

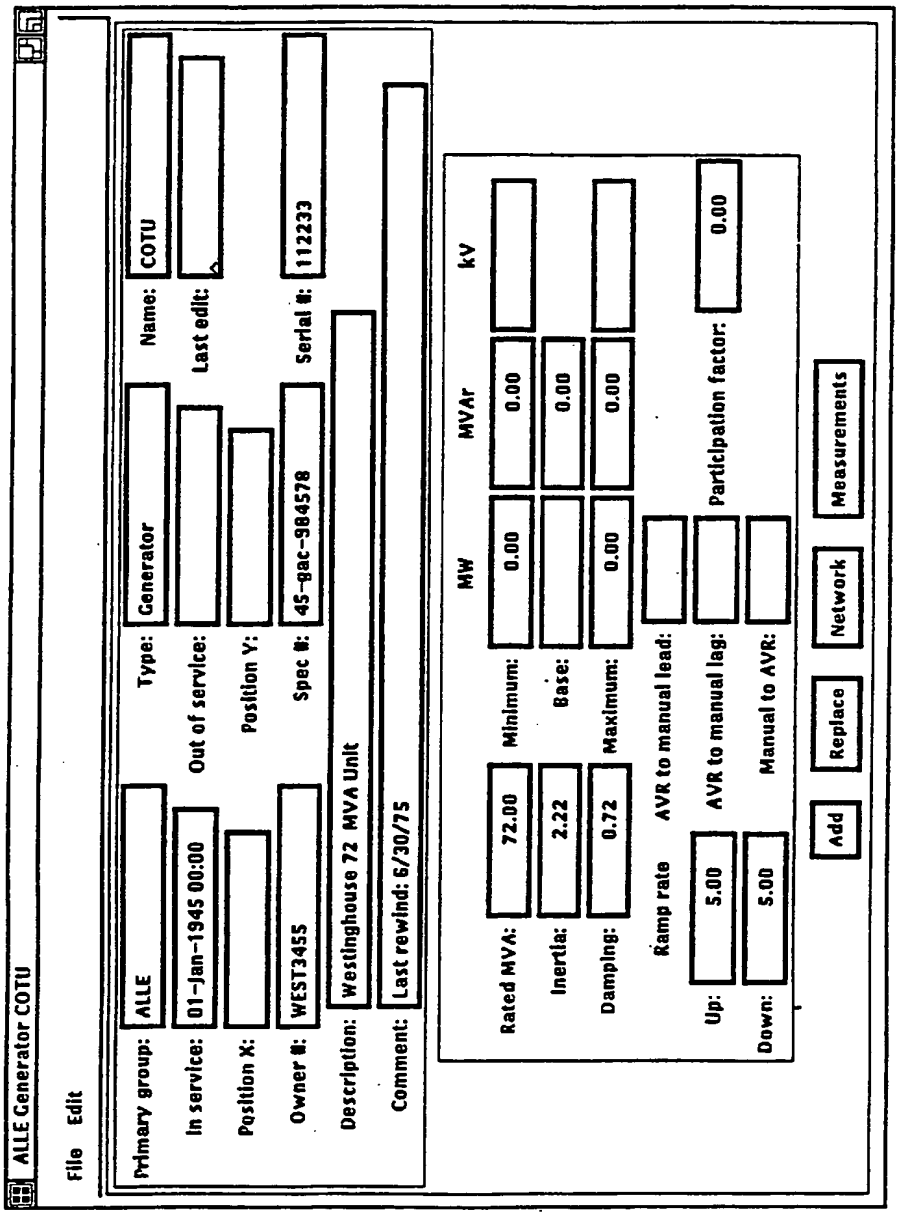
```
                QVexp = :C.QVexp,
                PFexp = :C.PFexp,
                QFexp = :C.QFexp
        WHERE   :Object = C.Object;

        COMMIT;
    END;

/*** temporary special for consumers - make it easy to chase up load model ***
ON Properties O.PrimaryGroupingName =
    BEGIN
        IF O.PrimaryGrouping != Object$Null THEN
            REPEATED
            SELECT  :OS.Object = O.Object,
                    :OS.BaseType = O.BaseType,
                    :OS.Type = O.Type,
                    :OS.PrimaryGrouping = O.PrimaryGrouping,
                    :OS.TypeName = O.TypeName,
                    :OS.Name = O.Name,
                    :OS.PrimaryGroupingName = O.PrimaryGroupingName
            FROM    Object O
            WHERE   :O.PrimaryGrouping = O.Object;

            CALLPROC ObjectEditor (OS = OS);
        ENDIF;

    END;
```



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*****************************************************************************/

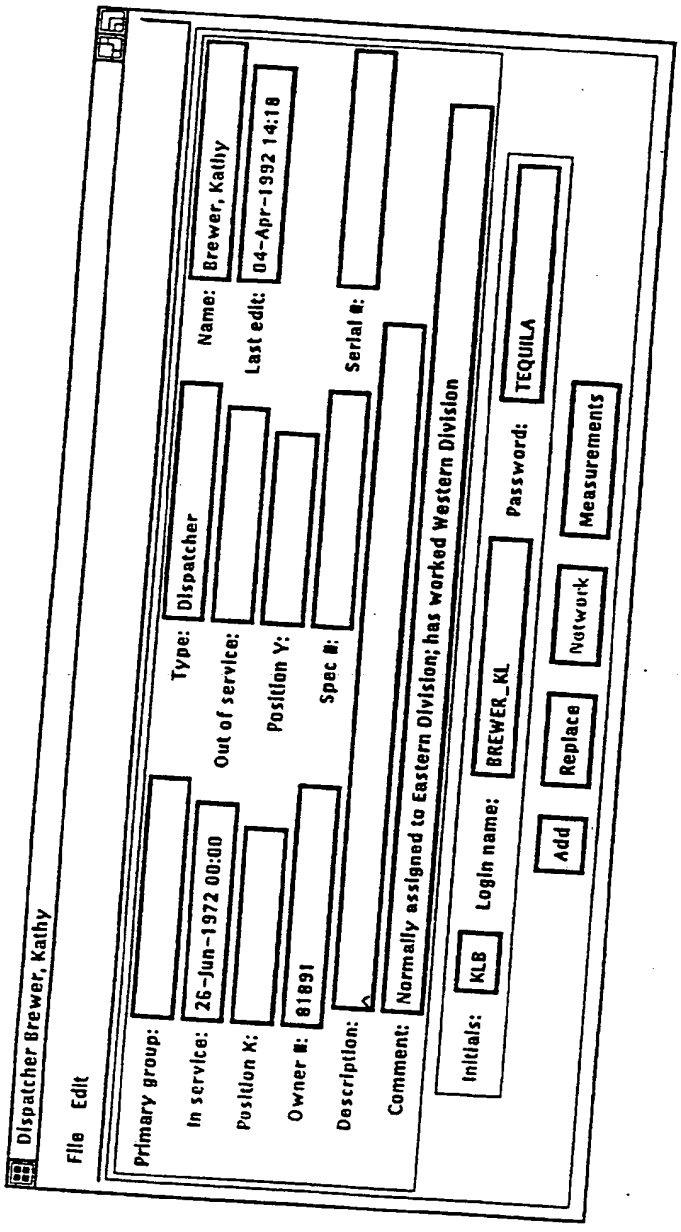
INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :G.Object = G.Object,
                :G.RatedMVA = G.RatedMVA,
                :G.MinimumMW = G.MinimumMW,
                :G.BaseMW = G.BaseMW,
                :G.MaximumMW = G.MaximumMW,
                :G.MinimumMVAr = G.MinimumMVAr,
                :G.BaseMVAr = G.BaseMVAr,
                :G.MaximumMVAr = G.MaximumMVAr,
                :G.MinimumkV = G.MinimumkV,
                :G.MaximumkV = G.MaximumkV,
                :G.X = G.X,
                :G.R = G.R,
                :G.Inertia = G.Inertia,
                :G.Damping = G.Damping,
                :G.ManualToAVR = G.ManualToAVR,
                :G.AVRToManualLag = G.AVRToManualLag,
                :G.AVRToManualLead = G.AVRToManualLead,
                :G.NormalPF = G.NormalPF,
                :G.ShortPF = G.ShortPF,
                :G.LongPF = G.LongPF,
                :G.DownRampRate = G.DownRampRate,
                :G.UpRampRate = G.UpRampRate
        FROM    Generator G
        WHERE   :Object = G.Object;

        ROLLBACK;
    END;
```

```
ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Generator G
        SET     RatedMVA = :G.RatedMVA,
                MinimumMW = :G.MinimumMW,
                BaseMW = :G.BaseMW,
                MaximumMW = :G.MaximumMW,
                MinimumMVAr = :G.MinimumMVAr,
                BaseMVAr = :G.BaseMVAr,
                MaximumMVAr = :G.MaximumMVAr,
                MinimumkV = :G.MinimumkV,
                MaximumkV = :G.MaximumkV,
                X = :G.X,
                R = :G.R,
                Inertia = :G.Inertia,
                Damping = :G.Damping,
                ManualToAVR = :G.ManualToAVR,
                AVRToManualLag = :G.AVRToManualLag,
                AVRToManualLead = :G.AVRToManualLead,
                NormalPF = :G.NormalPF,
                ShortPF = :G.ShortPF,
                LongPF = :G.LongPF,
                DownRampRate = :G.DownRampRate,
                UpRampRate = :G.UpRampRate
        WHERE   :Object = G.Object;

        COMMIT;
    END;
```



132.5

```
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        52.227-19, as applicable.

*****************************************************************************/

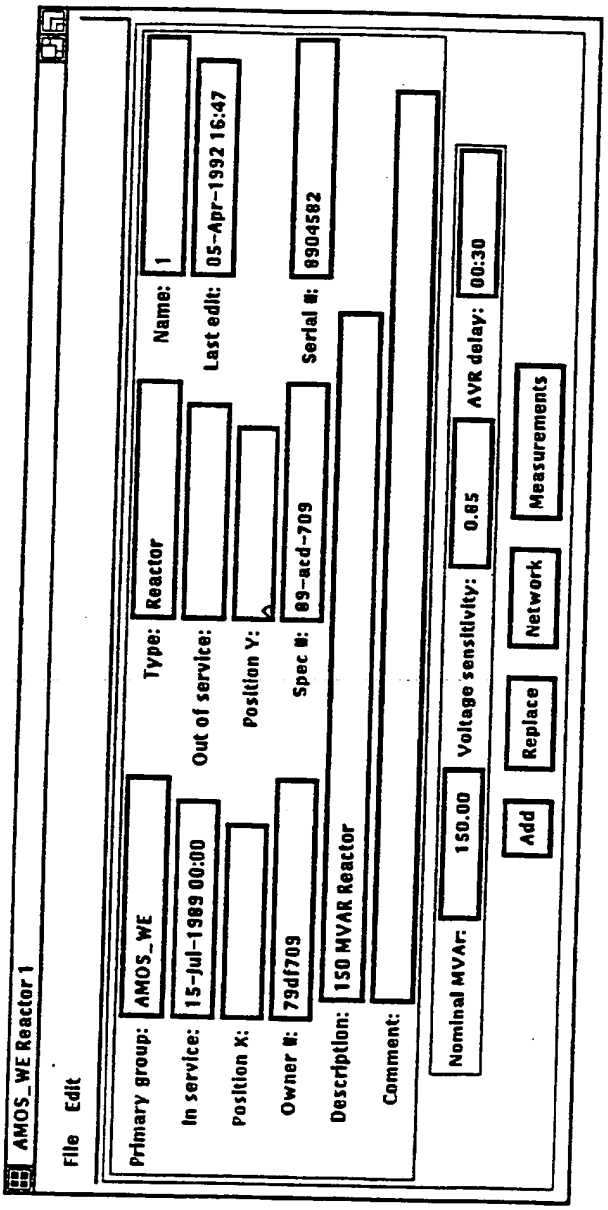
INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :P.Object = P.Object,
                :P.Initials = P.Initials,
                :P.LoginName = P.LoginName,
                :P.Password = P.Password
        FROM    Person P
        WHERE   :Object = P.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Person P
        SET     Initials = :P.Initials,
                LoginName = :P.LoginName,
                Password = :P.Password
        WHERE   :Object = P.Object;

        COMMIT;
    END;
```



```
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*****************************************************************************/

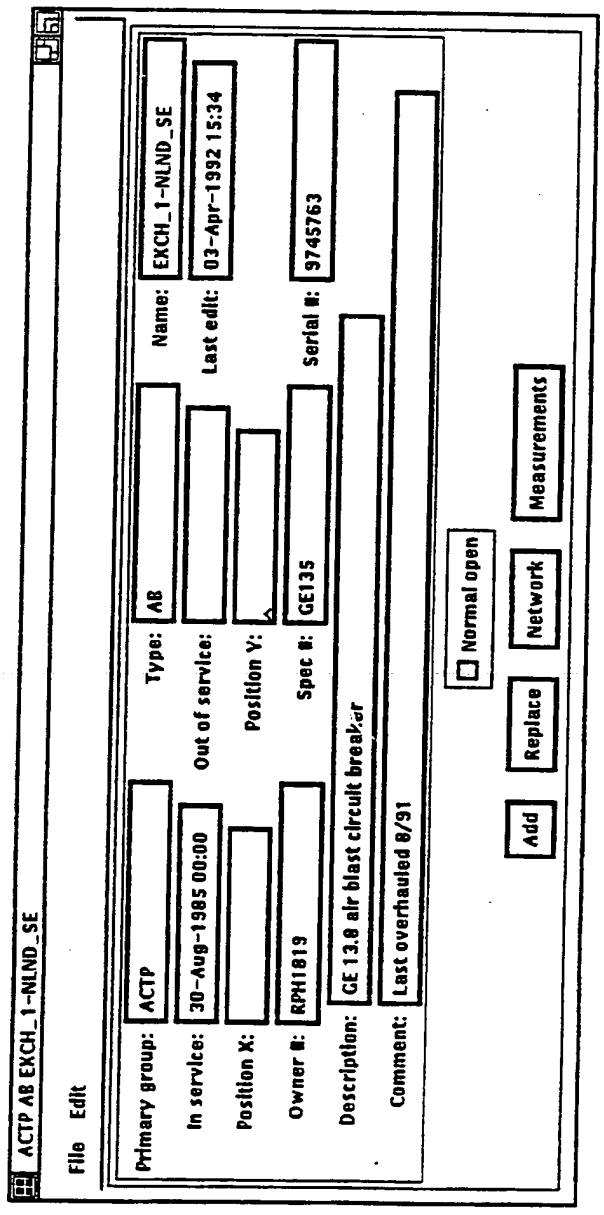
INITIALIZE
    (
    Object = INTEGER;                              /* Object being edited */
    OG = ARRAY OF GroupingClass;                   /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                /* Measurements made on it */
    RO = ObjectSummaryClass;                       /* Exchange replacement object
    i = INTEGER;                                   /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :R.Object = R.Object,
                :R.NominalMVAr = R.NominalMVAr,
                :R.VoltSensitivity = R.VoltSensitivity,
                :R.AVRDelay = R.AVRDelay
        FROM    Reactor R
        WHERE   :Object = R.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Reactor R
        SET     NominalMVAr = :R.NominalMVAr,
                VoltSensitivity = :R.VoltSensitivity,
                AVRDelay = :R.AVRDelay
        WHERE   :Object = R.Object;

        COMMIT;
    END;
```



```
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*****************************************************************************/

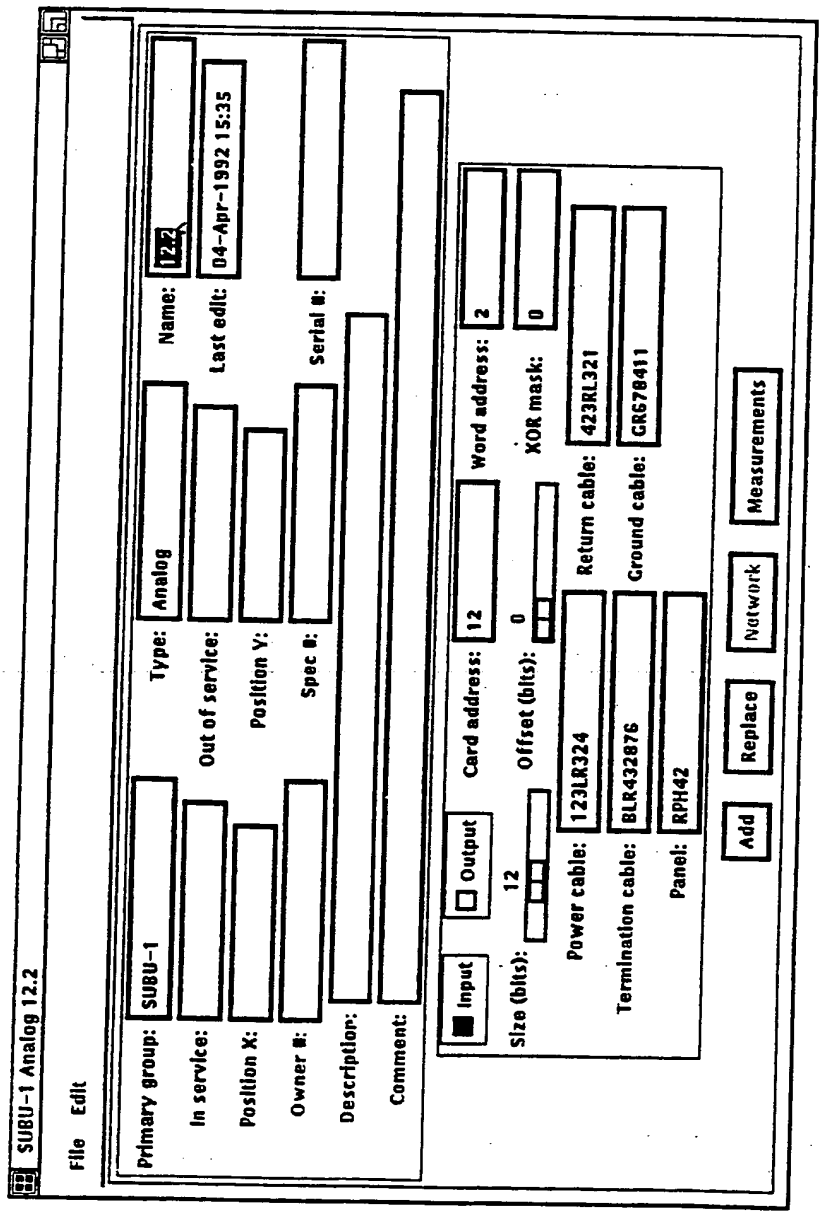
INITIALIZE
    (
    Object = INTEGER;                          /* Object being edited */
    OG = ARRAY OF GroupingClass;               /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;            /* Measurements made on it */
    RO = ObjectSummaryClass;                   /* Exchange replacement object
    i = INTEGER;                               /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :S.Object = S.Object,
                :S.NormalOpen = S.NormalOpen
        FROM    Switch S
        WHERE   :Object = S.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Switch S
        SET     NormalOpen = :S.NormalOpen
        WHERE   :Object = S.Object;

        COMMIT;
    END;
```



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*****************************************************************************/

INITIALIZE
    (
    Object = INTEGER;                          /* Object being edited */
    OG = ARRAY OF GroupingClass;               /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;            /* Measurements made on it */
    RO = ObjectSummaryClass;                   /* Exchange replacement object
    i = INTEGER;                               /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

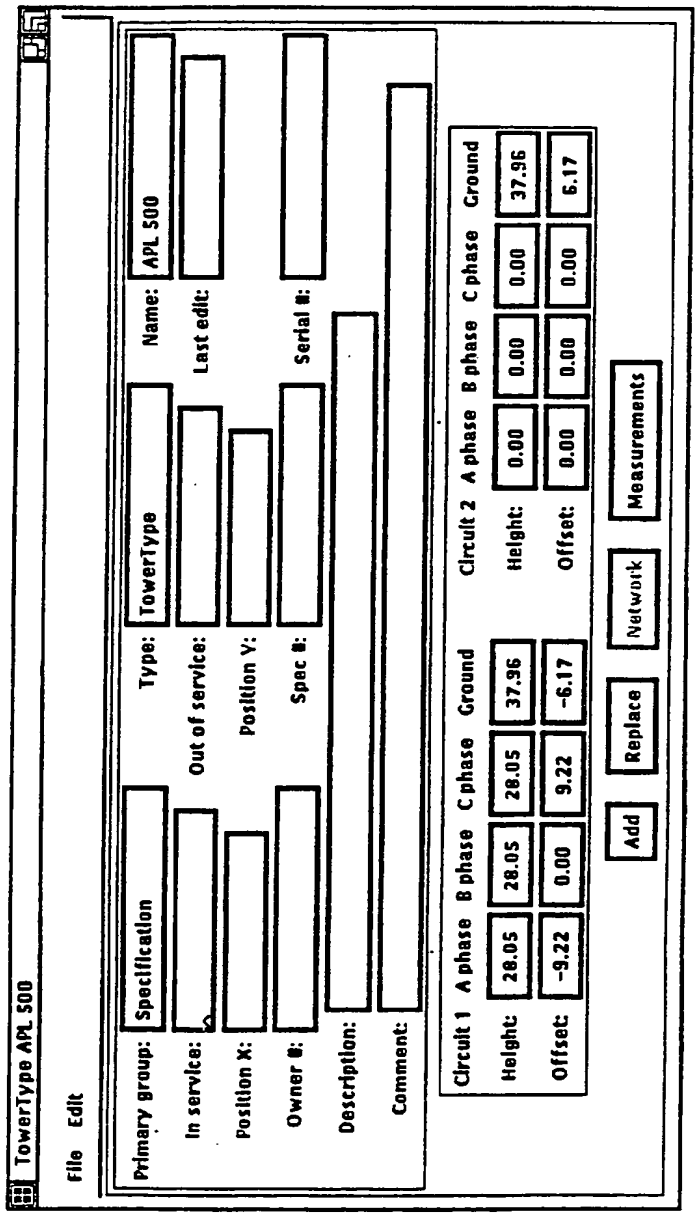
ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :T.Object = T.Object,
                :T.TelemetryMinimum = T.TelemetryMinimum,
                :T.TelemetryMaximum = T.TelemetryMaximum,
                :T.XORMask = T.XORMask,
                :T.Input = T.Input,
                :T.Output = T.Output,
                :T.CardAddress = T.CardAddress,
                :T.WordAddress = T.WordAddress,
                :T.Size = T.Size,
                :T.Offset = T.Offset,
                :T.PowerCable = T.PowerCable,
                :T.ReturnCable = T.ReturnCable,
                :T.GroundCable = T.GroundCable,
                :T.TerminationCable = T.TerminationCable,
                :T.Panel = T.Panel
        FROM    Telemetry T
        WHERE   :Object = T.Object;

        ROLLBACK;
    END;

ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Telemetry T
        SET     TelemetryMinimum = :T.TelemetryMinimum,
                TelemetryMaximum = :T.TelemetryMaximum,
                XORMask = :T.XORMask,
                Input = :T.Input,
                Output = :T.Output,
                CardAddress = :T.CardAddress,
                WordAddress = :T.WordAddress,
```

```
                Size = :T.Size,
                Offset = :T.Offset,
                PowerCable = :T.PowerCable,
                ReturnCable = :T.ReturnCable,
                GroundCable = :T.GroundCable,
                TerminationCable = :T.TerminationCable,
                Panel = :T.Panel
        WHERE   :Object = T.Object;

        COMMIT;
END;
```



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*****************************************************************************/

/*
**        Application:          PowerSystemModel
**        Frame:                TowerType
*/
INITIALIZE
    (
    Object = INTEGER;                                   /* Object being edited */
    OG = ARRAY OF GroupingClass;                        /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;                     /* Measurements made on it */
    RO = ObjectSummaryClass;                            /* Exchange replacement object */
    i = INTEGER;                                        /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

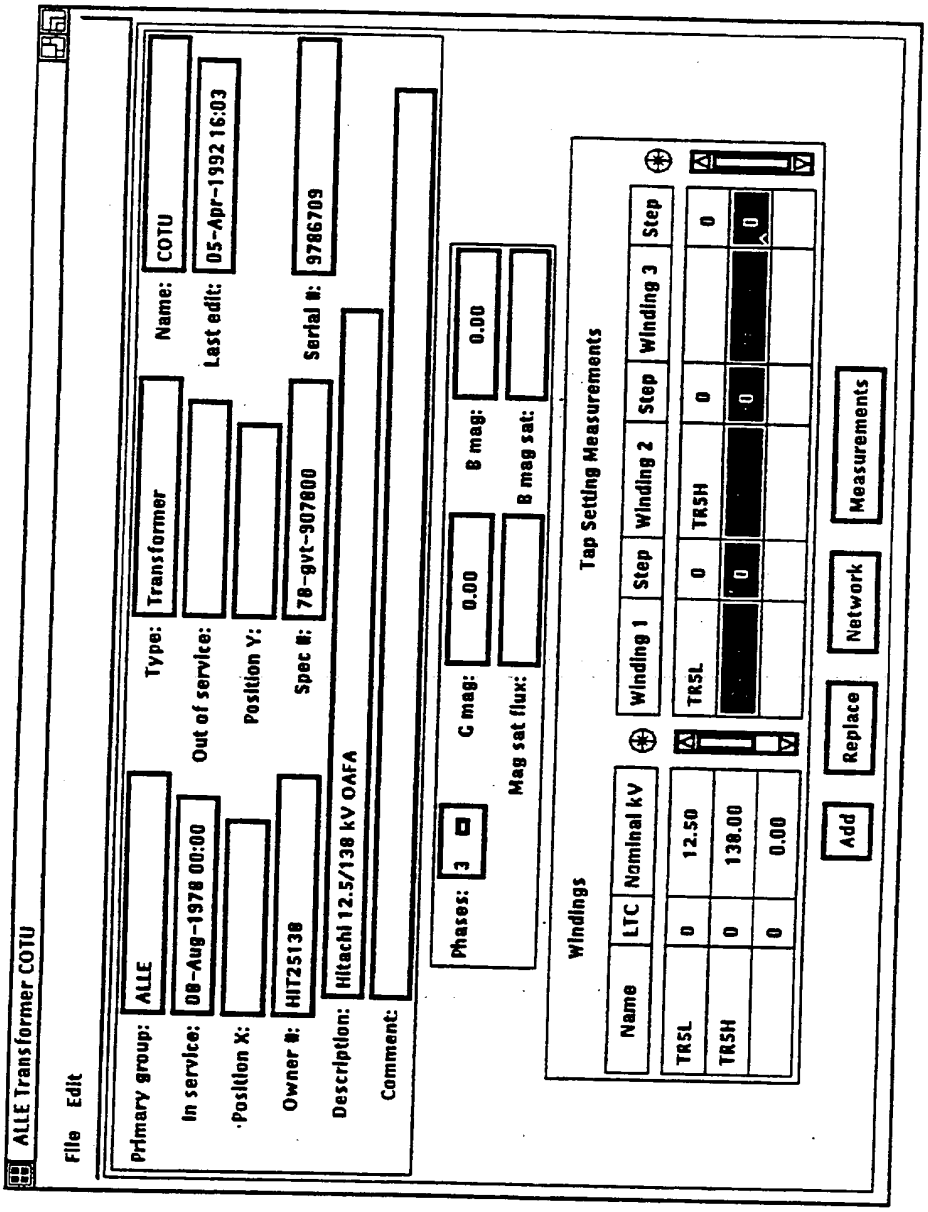
ON UserEvent 'T.GetAttributes'=
    BEGIN
/*
**        Get the tower details
*/
        REPEATED
        SELECT  :TT.A1_Offset = TT.A1_Offset,
                :TT.A1_Height = TT.A1_Height,
                :TT.B1_Offset = TT.B1_Offset,
                :TT.B1_Height = TT.B1_Height,
                :TT.C1_Offset = TT.C1_Offset,
                :TT.C1_Height = TT.C1_Height,
                :TT.G1_Offset = TT.G1_Offset,
                :TT.G1_Height = TT.G1_Height,
                :TT.A2_Offset = TT.A2_Offset,
                :TT.A2_Height = TT.A2_Height,
                :TT.B2_Offset = TT.B2_Offset,
                :TT.B2_Height = TT.B2_Height,
                :TT.C2_Offset = TT.C2_Offset,
                :TT.C2_Height = TT.C2_Height,
                :TT.G2_Offset = TT.G2_Offset,
                :TT.G2_Height = TT.G2_Height
        FROM    TowerType TT
        WHERE   :Object = TT.Object;

        ROLLBACK;
    END;
```

```
ON UserEvent 'T.Update' =

    BEGIN
        UPDATE  TowerType TT
        SET     A1_Offset = :TT.A1_Offset,
                A1_Height = :TT.A1_Height,
                B1_Offset = :TT.B1_Offset,
                B1_Height = :TT.B1_Height,
                C1_Offset = :TT.C1_Offset,
                C1_Height = :TT.C1_Height,
                G1_Offset = :TT.G1_Offset,
                G1_Height = :TT.G1_Height,
                A2_Offset = :TT.A2_Offset,
                A2_Height = :TT.A2_Height,
                B2_Offset = :TT.B2_Offset,
                B2_Height = :TT.B2_Height,
                C2_Offset = :TT.C2_Offset,
                C2_Height = :TT.C2_Height,
                G2_Offset = :TT.G2_Offset,
                G2_Height = :TT.G2_Height
        WHERE   :Object = TT.Object;

        COMMIT;
    END;
```



```
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*****************************************************************************/

INITIALIZE
    (
    Object = INTEGER;                           /* Object being edited */
    OG = ARRAY OF GroupingClass;                /* Groupings it belongs to */
    OM = ARRAY OF MeasurementClass;             /* Measurements made on it */
    RO = ObjectSummaryClass;                    /* Exchange replacement object
    i = INTEGER NOT NULL;                       /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent(EventName = 'O.GetAttributes');
    END;

ON UserEvent 'T.GetAttributes'=
    BEGIN
        REPEATED
        SELECT  :T.Object = T.Object,
                :T.Phases = T.Phases,
                :T.GMag = T.GMag,
                :T.BMag = T.BMag,
                :T.MagSatFlux = T.MagSatFlux,
                :T.BMagSat = T.BMagSat
        FROM    Transformer T
        WHERE   :Object = T.Object;
/*
 *      The number of terminals is determined by the number of windings,
 *      and can be changed. Set the terminal count in the object to 0 to
 *      prevent any confusion (especially if this is used as a template
 *      for an Add)
 */
        O.Terminals = 0;

        CurFrame.SendUserEvent(EventName = 'W.GetAttributes');
        CurFrame.SendUserEvent(EventName = 'TS.GetAttributes');
        ROLLBACK;
    END;

ON UserEvent 'W.GetAttributes' =
    BEGIN
/*
**        Get the winding data
*/
        i = 1;
        W.Clear();

        REPEATED
        SELECT  :W[i].Object = W.Object,
                :W[i].Winding = W.Winding,
```

```
                :W[i].Source = W.Source,
                :W[i].Name = W.Name,
                :W[i].LoadTapChanger = W.LoadTapChanger,
                :W[i].NominalKV = W.NominalKV,
                :W[i].NeutralKV = W.NeutralKV,
                :W[i].BIL = W.BIL,
                :W[i].RatedMVA = W.RatedMVA,
                :W[i].ShortTermMVA = W.ShortTermMVA,
                :W[i].EmergencyMVA = W.EmergencyMVA,
                :W[i].LowStep = W.LowStep,
                :W[i].HighStep = W.HighStep,
                :W[i].NeutralStep = W.NeutralStep,
                :W[i].StepSize = W.StepSize,
                :W[i].PhaseShift = W.PhaseShift
        FROM    Winding W
        WHERE   :Object = W.Object
        BEGIN
            i = i + 1;
        END;

        ROLLBACK;
END;
```

```
ON UserEvent 'TS.GetAttributes' =
    BEGIN
/*
**          Get the tap setting measurements
*/
        i = 1;
        TS.Clear();

        REPEATED
        SELECT  :TS[i].Object = TS.Object,
                :TS[i].Winding1 = TS.Winding1,
                :TS[i].TapStep1 = TS.TapStep1,
                :TS[i].Winding2 = TS.Winding2,
                :TS[i].TapStep2 = TS.TapStep2,
                :TS[i].Winding3 = TS.Winding3,
                :TS[i].TapStep3 = TS.TapStep3,
                :TS[i].Source = TS.Source,
                :TS[i].R0_1_2 = TS.R0_1_2,
                :TS[i].Z0_1_2 = TS.Z0_1_2,
                :TS[i].R1_1_2 = TS.R1_1_2,
                :TS[i].Z1_1_2 = TS.Z1_1_2,
                :TS[i].R0_2_3 = TS.R0_2_3,
                :TS[i].Z0_2_3 = TS.Z0_2_3,
                :TS[i].R1_2_3 = TS.R1_2_3,
                :TS[i].Z1_2_3 = TS.Z1_2_3,
                :TS[i].R0_3_1 = TS.R0_3_1,
                :TS[i].Z0_3_1 = TS.Z0_3_1,
                :TS[i].R1_3_1 = TS.R1_3_1,
                :TS[i].Z1_3_1 = TS.Z1_3_1,
                :TS[i].R0_1 = TS.R0_1,
                :TS[i].Z0_1 = TS.Z0_1,
                :TS[i].X0_1 = TS.X0_1,
                :TS[i].R1_1 = TS.R1_1,
                :TS[i].Z1_1 = TS.Z1_1,
                :TS[i].X1_1 = TS.X1_1,
                :TS[i].R0_2 = TS.R0_2,
                :TS[i].Z0_2 = TS.Z0_2,
                :TS[i].X0_2 = TS.X0_2,
                :TS[i].R1_2 = TS.R1_2,
                :TS[i].Z1_2 = TS.Z1_2,
                :TS[i].X1_2 = TS.X1_2,
                :TS[i].R0_3 = TS.R0_3,
                :TS[i].Z0_3 = TS.Z0_3,
                :TS[i].X0_3 = TS.X0_3,
                :TS[i].R1_3 = TS.R1_3,
                :TS[i].Z1_3 = TS.Z1_3,
                :TS[i].X1_3 = TS.X1_3
        FROM    TapSetting TS
        WHERE   :Object = TS.Object
        BEGIN

            IF TS[i].Winding1 != 0 THEN
                TS[i].Winding1Name = W[TS[i].Winding1].Name;
            ENDIF;

            IF TS[i].Winding2 != 0 THEN
                TS[i].Winding2Name = W[TS[i].Winding2].Name;
            ENDIF;

            IF TS[i].Winding3 != 0 THEN
                TS[i].Winding3Name = W[TS[i].Winding3].Name;
            ENDIF;

            i = i + 1;
        END;
```

```
    ROLLBACK;
END;
```

```
/*
**          Edit a transformer winding
*/
ON ChildProperties W =
    BEGIN
        IF FIELD(W).ActiveRow = 0 THEN
            RESUME;
        ENDIF;

        CALLFRAME SetWinding (Winding = W[]);
    END;

ON DeleteRow W =
    BEGIN
        IF FIELD(W).ActiveRow = 0 THEN
            RESUME;
        ENDIF;
/*
 *      Check that the winding is not referenced by a tap setting
 */
        i = 1;
        WHILE i <= TS.LastRow() DO

            IF TS[i].Winding1 = W[].Winding OR
               TS[i].Winding2 = W[].Winding OR
               TS[i].Winding3 = W[].Winding THEN
                FIELD(TS).ActiveRow = i;
                INSERT INTO GrassCatcher (Object, Text, Problem)
                    VALUES (:W[].Object, :W[].Name, 'Transformer_015');
                ROLLBACK;
                RESUME;
            ENDIF;

            i = i + 1;
        ENDWHILE;
/*
 *      Back up any references to windings beyond this one
 */
        i = 1;
        WHILE i <= TS.LastRow() DO

            IF TS[i].Winding1 > W[].Winding THEN
                TS[i].Winding1 = TS[i].Winding1 - 1;
            ENDIF;

            IF TS[i].Winding2 > W[].Winding THEN
                TS[i].Winding2 = TS[i].Winding2 - 1;
            ENDIF;

            IF TS[i].Winding3 > W[].Winding THEN
                TS[i].Winding3 = TS[i].Winding3 - 1;
            ENDIF;

            i = i + 1;
        ENDWHILE;

        W.RemoveRow(RowNumber = FIELD(W).CurRow);

    END;

ON ClearTable W =
    BEGIN

        IF TS.LastRow() != 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
```

```
            VALUES (:W[].Object, 'Transformer_016');
        ROLLBACK;
        RESUME;
    ENDIF;

    W.Clear();
END;
```

```
        Edit a transformer tap setting measurement

| ChildProperties TS =
    BEGIN
        IF FIELD(TS).ActiveRow = 0 THEN
            RESUME;
        ENDIF;

        OPENFRAME SetTapSetting (TapSetting = TS[], W = W) WITH
            WindowTitle = CurFrame.WindowTitle;
    END;
```

```
ON UserEvent 'T.Update' =
    BEGIN
        REPEATED
        UPDATE  Transformer T
        SET     Phases = :T.Phases,
                GMag = :T.GMag,
                BMag = :T.BMag,
                MagSatFlux = :T.MagSatFlux,
                BMagSat = :T.BMagSat
        WHERE   :Object = T.Object;

        CurFrame.SendUserEvent (EventName = 'W.Update');
        CurFrame.SendUserEvent (EventName = 'TS.Update');
        COMMIT;
    END;
```

```
ON UserEvent 'W.Update' =
    BEGIN
/*
 *      Preserve any terminals that are defined for the transformer by
 *      altering the terminal number so that it is not the same as the
 *      winding number, then delete all the windings.
 */
        REPEATED
        UPDATE  Terminal T
        SET     Terminal = -Terminal
        WHERE   :Object = T.Object;

        REPEATED
        DELETE FROM Winding W
                WHERE   :Object = W.Object;
/*
 *      Loop through the table field, inserting each winding in turn.
 */
        i = 1;

        WHILE i <= W.LastRow() DO
            REPEATED
            INSERT INTO Winding
                (Object
                ,Name
                ,LoadTapChanger
                ,NominalKV
                ,NeutralKV
                ,BIL
                ,RatedMVA
                ,ShortTermMVA
                ,EmergencyMVA
                ,LowStep
                ,HighStep
                ,NeutralStep
                ,StepSize
                ,PhaseShift
                )
            VALUES
                    (:Object
                ,:W[i].Name
                ,:W[i].LoadTapChanger
                ,:W[i].NominalKV
                ,:W[i].NeutralKV
                ,:W[i].BIL
                ,:W[i].RatedMVA
                ,:W[i].ShortTermMVA
                ,:W[i].EmergencyMVA
                ,:W[i].LowStep
                ,:W[i].HighStep
                ,:W[i].NeutralStep
                ,:W[i].StepSize
                ,:W[i].PhaseShift
                );

                IF IIErrorNumber != 0 THEN
                    FIELD(W).ActiveRow = i;
                    CurFrame.PurgeUserEvent();
                    ROLLBACK;
                    RESUME;
                ENDIF;

            i = i + 1;
        ENDWHILE;
/*
```

```
*       Update the new terminal associated with the winding with the
*       connectivity information from the old terminal that was
*       preserved above. The match is done on the KVlevel - this means
*       that is the NominalKV of a winding is changed the terminal
*       will get disconnected automatically and will have to be
*       reconnected by hand. Then blow the old terminals away and ensure
*/      that the object's maximum terminal count is correct.

        REPEATED
        UPDATE  Terminal NT
        FROM    Terminal OT
        SET     Node = OT.Node
        WHERE   :Object = NT.Object AND
                NT.Terminal > 0 AND
                :Object = OT.Object AND
                OT.Terminal < 0 AND
                OT.KVLevel = NT.KVLevel;

        REPEATED
        DELETE FROM Terminal
        WHERE   :Object = Object AND
                Terminal < 0;

        i = W.LastRow();
        REPEATED
        UPDATE  Object O
        SET     Terminals = :i
        WHERE   :Object = O.Object;

    COMMIT;
END;
```

```
ON UserEvent 'TS.Update' =
    BEGIN
/*
 *      Blow away all the current measurements, and replace
 *      them with a new set (too many things can be edited to allow
 *      clean identification of the old row)
 */
        REPEATED
        DELETE FROM TapSetting TS
        WHERE   :Object = TS.Object;

        i = 1;

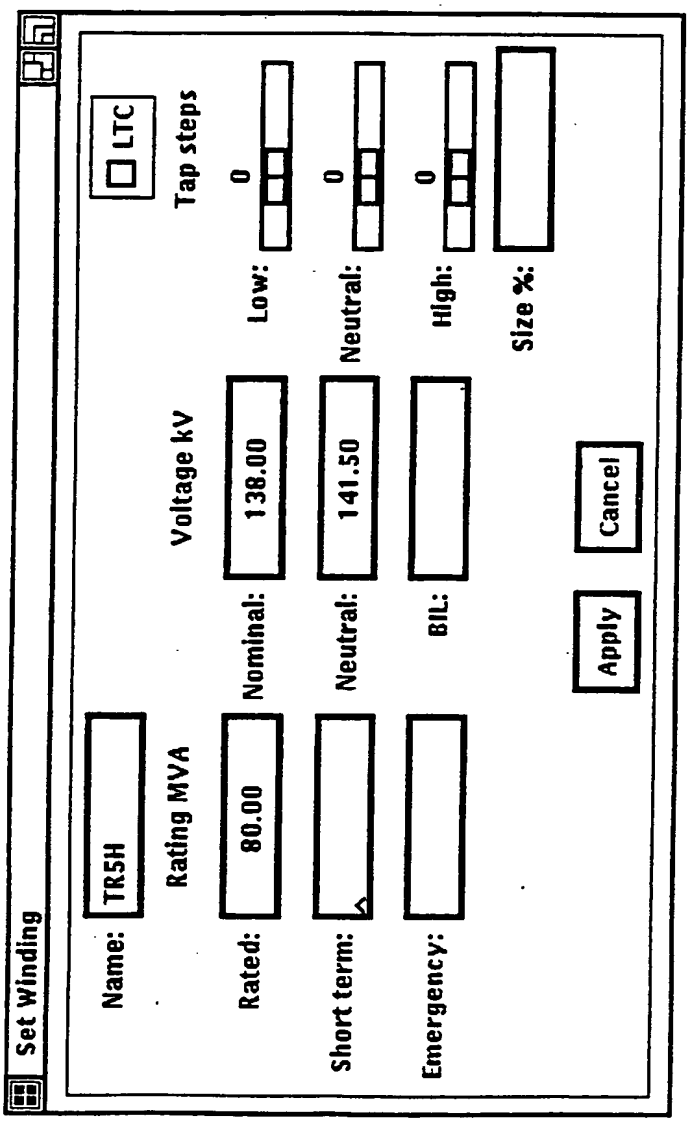
        WHILE i <= TS.LastRow() DO
/*
**        Insert the new measurements
*/
            REPEATED
            INSERT INTO TapSetting
                (
                Object,
                Winding1,
                TapStep1,
                Winding2,
                TapStep2,
                Winding3,
                TapStep3,
                Source,
                R1_1_2,
                Z1_1_2,
                R0_1_2,
                Z0_1_2,
                R1_2_3,
                Z1_2_3,
                R0_2_3,
                Z0_2_3,
                R1_3_1,
                Z1_3_1,
                R0_3_1,
                Z0_3_1,
                R1_1,
                Z1_1,
                X1_1,
                R0_1,
                Z0_1,
                X0_1,
                R1_2,
                Z1_2,
                X1_2,
                R0_2,
                Z0_2,
                X0_2,
                R1_3,
                Z1_3,
                X1_3,
                R0_3,
                Z0_3,
                X0_3
                )
            VALUES
                (
                :Object,
                :TS[i].Winding1,
                :TS[i].TapStep1,
                :TS[i].Winding2,
```

```
                    :TS[i].TapStep2,
                    :TS[i].Winding3,
                    :TS[i].TapStep3,
                    :TS[i].Source,
                    :TS[i].R1_1_2,
                    :TS[i].Z1_1_2,
                    :TS[i].R0_1_2,
                    :TS[i].Z0_1_2,
                    :TS[i].R1_2_3,
                    :TS[i].Z1_2_3,
                    :TS[i].R0_2_3,
                    :TS[i].Z0_2_3,
                    :TS[i].R1_3_1,
                    :TS[i].Z1_3_1,
                    :TS[i].R0_3_1,
                    :TS[i].Z0_3_1,
                    :TS[i].R1_1,
                    :TS[i].Z1_1,
                    :TS[i].X1_1,
                    :TS[i].R0_1,
                    :TS[i].Z0_1,
                    :TS[i].X0_1,
                    :TS[i].R1_2,
                    :TS[i].Z1_2,
                    :TS[i].X1_2,
                    :TS[i].R0_2,
                    :TS[i].Z0_2,
                    :TS[i].X0_2,
                    :TS[i].R1_3,
                    :TS[i].Z1_3,
                    :TS[i].X1_3,
                    :TS[i].R0_3,
                    :TS[i].Z0_3,
                    :TS[i].X0_3
                    );

                    IF IIErrorNumber != 0 THEN
                        FIELD(TS).ActiveRow = i;
                        CurFrame.PurgeUserEvent();
                        ROLLBACK;
                        RESUME;
                    ENDIF;

            i = i + 1;
        ENDWHILE;

        COMMIT;
    END;
```



```
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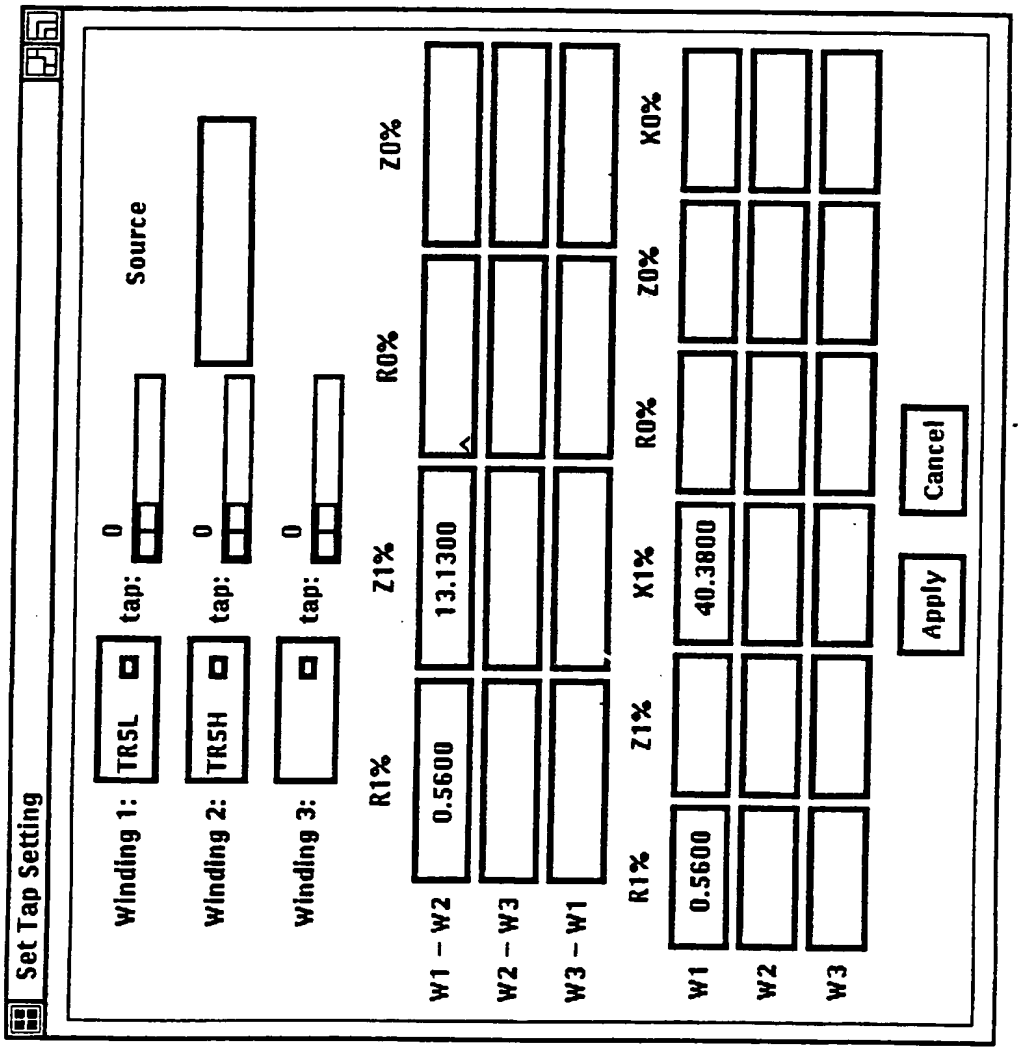
*****************************************************************************/

INITIALIZE
    (
    Winding = WindingClass;                    /* Passed winding */
    )=
    BEGIN
        W = Winding.Duplicate();
    END;

On Entry W.NominalKV =
    BEGIN
        W.NominalKV = CALLFRAME SetKVLevel (KVLevel = W.NominalKV);
        RESUME; /* Keep input focus out of this field */
    END;

ON Click Apply_Button =
    BEGIN
        Winding.Name = W.Name;
        Winding.LoadTapChanger = W.LoadTapChanger;
        Winding.NominalKV = W.NominalKV;
        Winding.NeutralKV = W.NeutralKV;
        Winding.BIL = W.BIL;
        Winding.RatedMVA = W.RatedMVA;
        Winding.ShortTermMVA = W.ShortTermMVA;
        Winding.EmergencyMVA = W.EmergencyMVA;
        Winding.LowStep = W.LowStep;
        Winding.HighStep = W.HighStep;
        Winding.NeutralStep = W.NeutralStep;
        Winding.StepSize = W.StepSize;
        Winding.PhaseShift = W.PhaseShift;
        RETURN TRUE;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN FALSE;
    END;
```



```
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*****************************************************************************/

INITIALIZE
    (
    TapSetting = TapSettingClass;                   /* Passed tap setting */
    W = ARRAY OF WindingClass;                      /* Passed windings */

    i = INTEGER NOT NULL;                           /* Scratch integer */

    MinValue = INTEGER;                             /* Min value for slider */
    MaxValue = INTEGER;                             /* Max value for slider */
    NameplateMVA = FLOAT;                           /* Rated MVA */
    KVCorrection = FLOAT;                           /* kV correction for tap setting */
    NameplateKV = FLOAT;                            /* kV of measurement */
    CF1 = FLOAT;                                    /* Winding 1 correction factor */
    CF2 = FLOAT;                                    /* Winding 2 correction factor */
    CF3 = FLOAT;                                    /* Winding 3 correction factor */
    )=
    BEGIN
        FIELD(TS.Winding1).ValueList.ChoiceItems.Clear();
        FIELD(TS.Winding1).ValueList.ChoiceItems[1].EnumValue = 0;
        FIELD(TS.Winding1).ValueList.ChoiceItems[1].EnumText = '';
        i = 1;

        WHILE i <= W.LastRow() DO
            FIELD(TS.Winding1).ValueList.ChoiceItems[i+1].EnumValue = i;
            FIELD(TS.Winding1).ValueList.ChoiceItems[i+1].EnumText = W[i].Name;
            i = i + 1;
        ENDWHILE;

        FIELD(TS.Winding2).ValueList = FIELD(TS.Winding1).ValueList;
        FIELD(TS.Winding3).ValueList = FIELD(TS.Winding1).ValueList;

        TS = TapSetting.Duplicate();

        CurFrame.SendUserEvent(EventName = 'TS.Winding1');
        CurFrame.SendUserEvent(EventName = 'TS.Winding2');
        CurFrame.SendUserEvent(EventName = 'TS.Winding3');
    END;
```

```
ON UserEvent 'TS.Winding1',
ON SetValue TS.Winding1 =

    BEGIN

        IF TS.Winding1 = 0 THEN
            MinValue = 0;
            MaxValue = 0;
        ELSE
            MinValue = W[TS.Winding1].LowStep;
            MaxValue = W[TS.Winding1].HighStep;
        ENDIF;

        IF  TS.TapStep1 < MinValue OR
            TS.TapStep1 > MaxValue THEN
            TS.TapStep1 = (MinValue + MaxValue) / 2;
        ENDIF;

        IF  MinValue = MaxValue THEN
            FIELD(TS.TapStep1).MinValue = MinValue;
            FIELD(TS.TapStep1).MaxValue = MaxValue + 1;
            FIELD(TS.TapStep1).UpdateBias = FB_Visible;
        ELSE
            FIELD(TS.TapStep1).MinValue = MinValue;
            FIELD(TS.TapStep1).MaxValue = MaxValue;
            FIELD(TS.TapStep1).UpdateBias = FB_Changeable;
        ENDIF;

    END;

ON UserEvent 'TS.Winding2',
ON SetValue TS.Winding2 =

    BEGIN

        IF TS.Winding2 = 0 THEN
            MinValue = 0;
            MaxValue = 0;
        ELSE
            MinValue = W[TS.Winding2].LowStep;
            MaxValue = W[TS.Winding2].HighStep;
        ENDIF;

        IF  TS.TapStep2 < MinValue OR
            TS.TapStep2 > MaxValue THEN
            TS.TapStep2 = (MinValue + MaxValue) / 2;
        ENDIF;

        IF  MinValue = MaxValue THEN
            FIELD(TS.TapStep2).MinValue = MinValue;
            FIELD(TS.TapStep2).MaxValue = MaxValue + 1;
            FIELD(TS.TapStep2).UpdateBias = FB_Visible;
        ELSE
            FIELD(TS.TapStep2).MinValue = MinValue;
            FIELD(TS.TapStep2).MaxValue = MaxValue;
            FIELD(TS.TapStep2).UpdateBias = FB_Changeable;
        ENDIF;

    END;

ON UserEvent 'TS.Winding3',
ON SetValue TS.Winding3 =

    BEGIN
```

```
    IF TS.Winding3 = 0 THEN
        MinValue = 0;
        MaxValue = 0;
    ELSE
        MinValue = W[TS.Winding3].LowStep;
        MaxValue = W[TS.Winding3].HighStep;
    ENDIF;

    IF  TS.TapStep3 < MinValue OR
        TS.TapStep3 > MaxValue THEN
        TS.TapStep3 = (MinValue + MaxValue) / 2;
    ENDIF;

    IF  MinValue = MaxValue THEN
        FIELD(TS.TapStep3).MinValue = MinValue;
        FIELD(TS.TapStep3).MaxValue = MaxValue + 1;
        FIELD(TS.TapStep3).UpdateBias = FB_Visible;
    ELSE
        FIELD(TS.TapStep3).MinValue = MinValue;
        FIELD(TS.TapStep3).MaxValue = MaxValue;
        FIELD(TS.TapStep3).UpdateBias = FB_Changeable;
    ENDIF;

END;
```

```
ON Click Apply_Button =
    BEGIN
        TapSetting.Winding1 = TS.Winding1;
        TapSetting.Winding1Name = FIELD(TS.Winding1).CurEnumText;
        TapSetting.TapStep1 = TS.TapStep1;
        TapSetting.Winding2 = TS.Winding2;
        TapSetting.Winding2Name = FIELD(TS.Winding2).CurEnumText;
        TapSetting.TapStep2 = TS.TapStep2;
        TapSetting.Winding3 = TS.Winding3;
        TapSetting.Winding3Name = FIELD(TS.Winding3).CurEnumText;
        TapSetting.TapStep3 = TS.TapStep3;
        TapSetting.Source = TS.Source;
        TapSetting.R1_1_2 = TS.R1_1_2;
        TapSetting.Z1_1_2 = TS.Z1_1_2;
        TapSetting.R0_1_2 = TS.R0_1_2;
        TapSetting.Z0_1_2 = TS.Z0_1_2;
        TapSetting.R1_2_3 = TS.R1_2_3;
        TapSetting.Z1_2_3 = TS.Z1_2_3;
        TapSetting.R0_2_3 = TS.R0_2_3;
        TapSetting.Z0_2_3 = TS.Z0_2_3;
        TapSetting.R1_3_1 = TS.R1_3_1;
        TapSetting.Z1_3_1 = TS.Z1_3_1;
        TapSetting.R0_3_1 = TS.R0_3_1;
        TapSetting.Z0_3_1 = TS.Z0_3_1;
        TapSetting.R1_1 = TS.R1_1;
        TapSetting.Z1_1 = TS.Z1_1;
        TapSetting.X1_1 = TS.X1_1;
        TapSetting.R0_1 = TS.R0_1;
        TapSetting.Z0_1 = TS.Z0_1;
        TapSetting.X0_1 = TS.X0_1;
        TapSetting.R1_2 = TS.R1_2;
        TapSetting.Z1_2 = TS.Z1_2;
        TapSetting.X1_2 = TS.X1_2;
        TapSetting.R0_2 = TS.R0_2;
        TapSetting.Z0_2 = TS.Z0_2;
        TapSetting.X0_2 = TS.X0_2;
        TapSetting.R1_3 = TS.R1_3;
        TapSetting.Z1_3 = TS.Z1_3;
        TapSetting.X1_3 = TS.X1_3;
        TapSetting.R0_3 = TS.R0_3;
        TapSetting.Z0_3 = TS.Z0_3;
        TapSetting.X0_3 = TS.X0_3;
        RETURN;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN;
    END;
```

```
ON ChildSetValue TS =
    BEGIN
        IF TS.Z1_1_2 IS NULL THEN
            RESUME NEXT;
        ENDIF;
/*
**          Check that the windings are set up OK
*/
        IF TS.Winding1 = 0 OR TS.Winding2 = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:TS.Object, 'Transformer_011');
            RESUME NEXT;
        ENDIF;

        IF TS.Winding1 = TS.Winding2 OR
           TS.Winding1 = TS.Winding3 OR
           TS.Winding2 = TS.Winding3 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:TS.Object, 'Transformer_012');
            RESUME NEXT;
        ENDIF;
/*
**          Figure out the MVA correction
*/
        i = 1;
        NameplateMVA = 0;

        WHILE i <= W.LastRow() DO

            IF W[i].RatedMVA > NameplateMVA THEN
                NameplateMVA = W[i].RatedMVA;
            ENDIF;

            i = i + 1;
        ENDWHILE;

        IF NameplateMVA = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:TS.Object, 'Transformer_013');
            RESUME NEXT;
        ENDIF;
/*
**          Do a sanity check on the measurements
*/
        IF TS.Z1_1_2 < 3.0 OR TS.Z1_1_2 > 15.0 OR
           TS.Z1_2_3 < 3.0 OR TS.Z1_2_3 > 15.0 OR
           TS.Z1_3_1 < 3.0 OR TS.Z1_3_1 > 15.0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:TS.Object, 'Transformer_014');
        ENDIF;
/*
**          Figure out the voltage correction for each winding
*/
        KVCorrection = (TS.TapStep1 - W[TS.Winding1].NeutralStep) *
            IFNULL(W[TS.Winding1].StepSize, 0.0);
        NameplateKV = W[TS.Winding1].NeutralKV + KVCorrection;
        CF1 = ((NameplateKV / W[TS.Winding1].NominalKV) ** 2) *
            (SP.MVABase / NameplateMVA);

        KVCorrection = (TS.TapStep2 - W[TS.Winding2].NeutralStep) *
            IFNULL(W[TS.Winding2].StepSize, 0.0);
        NameplateKV = W[TS.Winding2].NeutralKV + KVCorrection;
        CF2 = ((NameplateKV / W[TS.Winding2].NominalKV) ** 2) *
            (SP.MVABase / NameplateMVA);
/*
```

```
**        Calculate the per-winding impedances etc
*/
       IF TS.Winding3 = 0 AND
          TS.Z1_1_2 IS NOT NULL THEN

           TS.Z1_1 = 0.5 * TS.Z1_1_2 * CF1;
           TS.Z1_2 = 0.5 * TS.Z1_1_2 * CF2;
           TS.R1_1 = IFNULL(0.5 * TS.R1_1_2, 0.0) * CF1;
           TS.R1_2 = IFNULL(0.5 * TS.R1_1_2, 0.0) * CF2;

           IF TS.Z0_1_2 IS NOT NULL THEN
               TS.Z0_1 = 0.5 * TS.Z0_1_2 * CF1;
               TS.Z0_2 = 0.5 * TS.Z0_1_2 * CF2;
               TS.R0_1 = IFNULL(0.5 * TS.R0_1_2 * CF1, 0.0);
               TS.R0_2 = IFNULL(0.5 * TS.R0_1_2 * CF2, 0.0);
           ENDIF;

           TS.X1_1 = ((TS.Z1_1 ** 2) - (TS.R1_1 **2)) ** 0.5;
           TS.X1_2 = ((TS.Z1_2 ** 2) - (TS.R1_2 **2)) ** 0.5;

           TS.X0_1 = ((TS.Z0_1 ** 2) - (TS.R0_1 **2)) ** 0.5;
           TS.X0_2 = ((TS.Z0_2 ** 2) - (TS.R0_2 **2)) ** 0.5;

       ELSEIF TS.Z1_1_2 IS NOT NULL AND
              TS.Z1_3_1 IS NOT NULL AND
              TS.Z1_2_3 IS NOT NULL THEN

           KVCorrection = (TS.TapStep3 - W[TS.Winding3].NeutralStep) *
               IFNULL(W[TS.Winding3].StepSize, 0.0);
           NameplateKV = W[TS.Winding3].NeutralKV + KVCorrection;
           CF3 = ((NameplateKV / W[TS.Winding3].NominalKV) ** 2) *
               (SP.MVABase / NameplateMVA);

           TS.Z1_1 = 0.5 * (TS.Z1_1_2 + TS.Z1_3_1 - TS.Z1_2_3) * CF1;
           TS.Z1_2 = 0.5 * (TS.Z1_2_3 + TS.Z1_1_2 - TS.Z1_3_1) * CF2;
           TS.Z1_3 = 0.5 * (TS.Z1_3_1 + TS.Z1_2_3 - TS.Z1_1_2) * CF3;
           TS.R1_1 = IFNULL(0.5 * (TS.R1_1_2 + TS.R1_3_1 - TS.R1_2_3) * CF1, 0.
           TS.R1_2 = IFNULL(0.5 * (TS.R1_2_3 + TS.R1_1_2 - TS.R1_3_1) * CF2, 0.
           TS.R1_3 = IFNULL(0.5 * (TS.R1_3_1 + TS.R1_2_3 - TS.R1_1_2) * CF3, 0.

           IF TS.Z0_1_2 IS NOT NULL OR
              TS.Z0_3_1 IS NOT NULL OR
              TS.Z0_2_3 IS NOT NULL THEN
               TS.Z0_1 = 0.5 * (TS.Z0_1_2 + TS.Z0_3_1 - TS.Z0_2_3) * CF1;
               TS.Z0_2 = 0.5 * (TS.Z0_2_3 + TS.Z0_1_2 - TS.Z0_3_1) * CF2;
               TS.Z0_3 = 0.5 * (TS.Z0_3_1 + TS.Z0_2_3 - TS.Z0_1_2) * CF3;
               TS.R0_1 = IFNULL(0.5 * (TS.R0_1_2 + TS.R0_3_1 - TS.R0_2_3) * CF1
               TS.R0_2 = IFNULL(0.5 * (TS.R0_2_3 + TS.R0_1_2 - TS.R0_3_1) * CF1
               TS.R0_3 = IFNULL(0.5 * (TS.R0_3_1 + TS.R0_2_3 - TS.R0_1_2) * CF1
           ENDIF;

           TS.X1_1 = ((TS.Z1_1 ** 2) - (TS.R1_1 ** 2)) ** 0.5;
           TS.X1_2 = ((TS.Z1_2 ** 2) - (TS.R1_2 ** 2)) ** 0.5;
           TS.X1_3 = ((TS.Z1_3 ** 2) - (TS.R1_3 ** 2)) ** 0.5;

           TS.X0_1 = ((TS.Z0_1 ** 2) - (TS.R0_1 ** 2)) ** 0.5;
           TS.X0_2 = ((TS.Z0_2 ** 2) - (TS.R0_2 ** 2)) ** 0.5;
           TS.X0_3 = ((TS.Z0_3 ** 2) - (TS.R0_3 ** 2)) ** 0.5;
/*
**      Give the reactance the sign of the impedance
*/
           IF TS.Z1_1 < 0 THEN
               TS.X1_1 = - TS.X1_1;
           ENDIF;

           IF TS.Z1_2 < 0 THEN
```

```
            TS.X1_2 = - TS.X1_2;
        ENDIF;

        IF TS.Z1_3 < 0 THEN
            TS.X1_3 = - TS.X1_3;
        ENDIF;

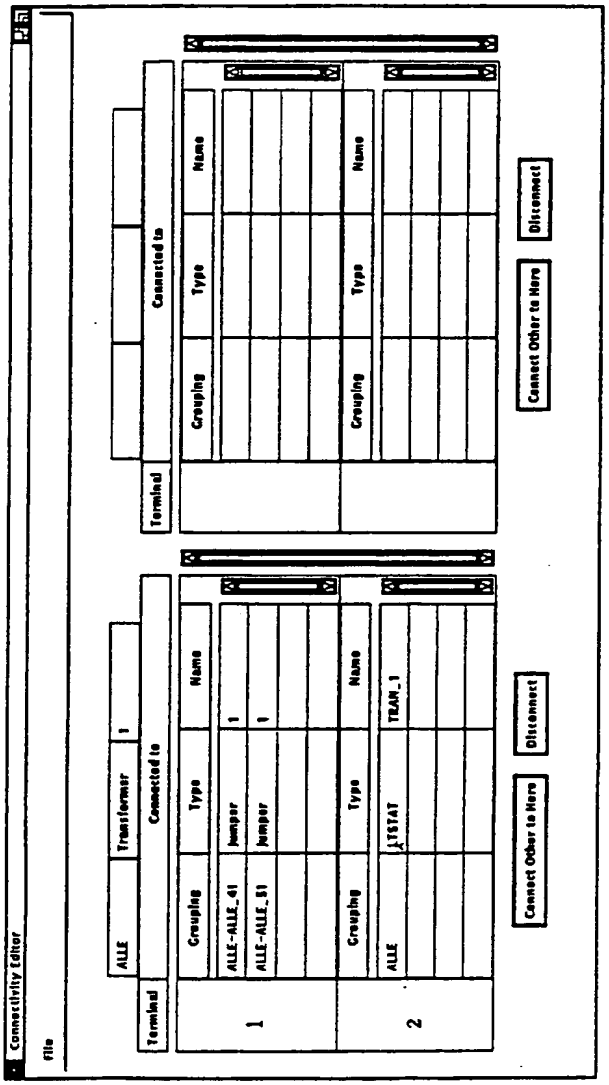
        IF TS.Z0_1 < 0 THEN
            TS.X0_1 = - TS.X0_1;
        ENDIF;

        IF TS.Z0_2 < 0 THEN
            TS.X0_2 = - TS.X0_2;
        ENDIF;

        IF TS.Z0_3 < 0 THEN
            TS.X0_3 = - TS.X0_3;
        ENDIF;

    ENDIF;

END;
```



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*****************************************************************************/

/*
**      Application:            PowerSystemModel
**      Frame:                  ConnectivityEditor
*/
INITIALIZE
    (
    T_Row = INTEGER;                                    /* Row number */
    C_Row = INTEGER;                                    /* Row number */
    ChoiceItem = INTEGER;                               /* Choice item in list */
    FrameName = VARCHAR(20) NOT NULL;                   /* Editor frame name */
    i = INTEGER NOT NULL;                               /* Scratch integer */
    dummy = INTEGER;                                    /* Scratch integer */
    )=
    BEGIN
        CurFrame.SendUserEvent (EventName = 'Close');
    END;
```

```
ON ChildProperties D1.T[*].C =
    BEGIN
        CALLPROC ObjectEditor (OS = D1.T[].C[]);
    END;

ON ChildDetails D1.T[*].C =
    BEGIN
        CurFrame.SendUserEvent(EventName = 'LoadObject_D1',
                               MessageInteger = D1.T[].C[].Object);
    END;

ON UserEvent 'LoadObject_D1' =
    BEGIN
        CurFrame.WindowVisibility = WV_Visible;
/*
 *      Get a desription of the object
 */
        REPEATED
        SELECT  :D1.O.Object = O.Object,
                :D1.O.BaseType = O.BaseType,
                :D1.O.Type = O.Type,
                :D1.O.PrimaryGrouping = O.PrimaryGrouping,
                :D1.O.Name = O.Name,
                :D1.O.TypeName = O.TypeName,
                :D1.O.PrimaryGroupingName = O.PrimaryGroupingName,
                :dummy = :i
        FROM    Object O
        WHERE   :CurFrame.MessageInteger = O.Object;
/*
 *        Get the terminals for the object
 */
        D1.T.Clear();
        T_Row = 1;

        REPEATED
        SELECT  :D1.T[T_Row].Object = T.Object,
                :D1.T[T_Row].Terminal = T.Terminal,
                :D1.T[T_Row].Node = T.Node,
                :D1.T[T_Row].KVLevel = T.KVLevel,
                :dummy = :i
        FROM    Terminal T
        WHERE   :D1.O.Object = T.Object
        BEGIN
            FIELD(D1.T[T_Row].Terminal).IsReverse = FALSE;
/*
 *        Load up all the things connected to this terminal
 */
            D1.T[T_Row].C.Clear();
            C_Row = 1;

            REPEATED
            SELECT  :D1.T[T_Row].C[C_Row].Object = O.Object,
                    :D1.T[T_Row].C[C_Row].BaseType = O.BaseType,
                    :D1.T[T_Row].C[C_Row].Type = O.Type,
                    :D1.T[T_Row].C[C_Row].PrimaryGrouping = O.PrimaryGrouping,
                    :D1.T[T_Row].C[C_Row].TypeName = O.TypeName,
                    :D1.T[T_Row].C[C_Row].Name = O.Name,
                    :D1.T[T_Row].C[C_Row].PrimaryGroupingName = O.PrimaryGroupi:
                    :dummy = :i
            FROM    Terminal T,
                    Object O
            WHERE   :D1.T[T_Row].Node != :Node$Floating AND
                    :D1.T[T_Row].Node = T.Node AND
                    :D1.T[T_Row].Object != T.Object AND
                    T.Object = O.Object
```

```
            BEGIN
                C_Row = C_Row + 1;
            END;

            T_Row = T_Row + 1;
        END;

        ROLLBACK;
END;
```

```
ON ChildProperties D2.T[*].C =
    BEGIN
        CALLPROC ObjectEditor (OS = D2.T[].C[]);
    END;

ON ChildDetails D2.T[*].C =
    BEGIN
        CurFrame.SendUserEvent(EventName = 'LoadObject_D2',
                               MessageInteger = D2.T[].C[].Object);
    END;

ON UserEvent 'LoadObject_D2' =

    BEGIN
        CurFrame.WindowVisibility = WV_Visible;
/*
 *      Get a desription of the object
 */
        REPEATED
        SELECT  :D2.O.Object = O.Object,
                :D2.O.BaseType = O.BaseType,
                :D2.O.Type = O.Type,
                :D2.O.PrimaryGrouping = O.PrimaryGrouping,
                :D2.O.Name = O.Name,
                :D2.O.TypeName = O.TypeName,
                :D2.O.PrimaryGroupingName = O.PrimaryGroupingName,
                :dummy = :i
        FROM    Object O
        WHERE   :CurFrame.MessageInteger = O.Object;
/*
 *        Get the terminals for the object
 */
        D2.T.Clear();
        T_Row = 1;

        REPEATED
        SELECT  :D2.T[T_Row].Object = T.Object,
                :D2.T[T_Row].Terminal = T.Terminal,
                :D2.T[T_Row].Node = T.Node,
                :D2.T[T_Row].KVLevel = T.KVLevel,
                :dummy = :i
        FROM    Terminal T
        WHERE   :D2.O.Object = T.Object
        BEGIN
            FIELD(D2.T[T_Row].Terminal).IsReverse = FALSE;
/*
 *        Load up all the things connected to this terminal
 */
            D2.T[T_Row].C.Clear();
            C_Row = 1;

            REPEATED
            SELECT  :D2.T[T_Row].C[C_Row].Object = O.Object,
                    :D2.T[T_Row].C[C_Row].BaseType = O.BaseType,
                    :D2.T[T_Row].C[C_Row].Type = O.Type,
                    :D2.T[T_Row].C[C_Row].PrimaryGrouping = O.PrimaryGrouping,
                    :D2.T[T_Row].C[C_Row].TypeName = O.TypeName,
                    :D2.T[T_Row].C[C_Row].Name = O.Name,
                    :D2.T[T_Row].C[C_Row].PrimaryGroupingName = O.PrimaryGroupi
                    :dummy = :i
            FROM    Terminal T,
                    Object O
            WHERE   :D2.T[T_Row].Node != :Node$Floating AND
                    :D2.T[T_Row].Node = T.Node AND
                    :D2.T[T_Row].Object != T.Object AND
```

```
                T.Object = O.Object
        BEGIN
            C_Row = C_Row + 1;
        END;

        T_Row = T_Row + 1;
    END;

    ROLLBACK;
END;
```

```
ON Click D1_Connect =

    BEGIN
        IF FIELD(D1.T).CurrentRow = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:D1.O.Object, 'Object_008');
            ROLLBACK;
            RESUME;
        ENDIF;

        IF FIELD(D2.T).CurrentRow = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:D1.O.Object, 'Object_009');
            ROLLBACK;
            RESUME;
        ENDIF;
/*
 *      If both the terminals are already connected to the same node,
 *      then assume that the user wishes to break them away from that
 *      node. If the user is trying to connect to a disconnected terminal,
 *      assume that they mean it. Create a new node, and assign the terminal
 *      "to connect to" to the new node.
 */
        IF D1.T[].Node = D2.T[].Node OR
           D1.T[].Node = Node$Floating THEN
            UPDATE  LastKey
            SET     Value = Value + 1
            WHERE   LastKey = 'Node';

            SELECT  :D1.T[].Node = Value
            FROM    LastKey
            WHERE   LastKey = 'Node';

            UPDATE  Terminal
            SET     Node = :D1.T[].Node
            WHERE   Object = :D1.T[].Object AND
                    Terminal = :D1.T[].Terminal;
        ENDIF;
/*
 *      Connect the terminals by copying the "to connect to" terminal's node
 *      to the "to be connected" terminal's node.
 */
        REPEATED
        UPDATE  Terminal
        SET     Node = :D1.T[].Node
        WHERE   Object = :D2.T[].Object AND
                Terminal = :D2.T[].Terminal;

        COMMIT;
        CurFrame.SendUserEvent (EventName = 'LoadObject_D1',
                                MessageInteger = D1.O.Object);
        CurFrame.SendUserEvent (EventName = 'LoadObject_D2',
                                MessageInteger = D2.O.Object);
    END;
```

```
ON Click D2_Connect =

    BEGIN
        IF FIELD(D2.T).CurrentRow = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:D2.O.Object, 'Object_008');
            ROLLBACK;
            RESUME;
        ENDIF;

        IF FIELD(D1.T).CurrentRow = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:D2.O.Object, 'Object_009');
            ROLLBACK;
            RESUME;
        ENDIF;
/*
 *      If both the terminals are already connected to the same node,
 *      then assume that the user wishes to break them away from that
 *      node. If the user is trying to connect to a disconnected terminal,
 *      assume that they mean it. Create a new node, and assign the terminal
 *      "to connect to" to the new node.
 */
        IF D2.T[].Node = D1.T[].Node OR
           D2.T[].Node = Node$Floating THEN
            UPDATE  LastKey
            SET     Value = Value + 1
            WHERE   LastKey = 'Node';

            SELECT  :D2.T[].Node = Value
            FROM    LastKey
            WHERE   LastKey = 'Node';

            UPDATE  Terminal
            SET     Node = :D2.T[].Node
            WHERE   Object = :D2.T[].Object AND
                    Terminal = :D2.T[].Terminal;
        ENDIF;
/*
 *      Connect the terminals by copying the "to connect to" terminal's node
 *      to the "to be connected" terminal's node.
 */
        REPEATED
        UPDATE  Terminal
        SET     Node = :D2.T[].Node
        WHERE   Object = :D1.T[].Object AND
                Terminal = :D1.T[].Terminal;

        COMMIT;
        CurFrame.SendUserEvent (EventName = 'LoadObject_D2',
                                MessageInteger = D2.O.Object);
        CurFrame.SendUserEvent (EventName = 'LoadObject_D1',
                                MessageInteger = D1.O.Object);
    END;
```

```
ON ChildEntry D1.T =

    BEGIN
        i = 1;

        WHILE i <= D1.T.LastRow() DO
            FIELD(D1.T[i].Terminal).IsReverse = FALSE;
            i = i + 1;
        ENDWHILE;

        FIELD(D1.T[].Terminal).IsReverse = TRUE;
    END;

ON ChildEntry D2.T =

    BEGIN
        i = 1;

        WHILE i <= D2.T.LastRow() DO
            FIELD(D2.T[i].Terminal).IsReverse = FALSE;
            i = i + 1;
        ENDWHILE;

        FIELD(D2.T[].Terminal).IsReverse = TRUE;
    END;
```

```
ON Click D1_Disconnect =

    BEGIN
        i = FIELD(D1.T).CurRow;

        IF i = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:D1.O.Object, 'Object_010');
            ROLLBACK;
            RESUME;
        ENDIF;

        UPDATE  Terminal T
        SET     Node = :Node$Floating
        WHERE   :D1.T[].Object = T.Object AND
                :D1.T[].Terminal = T.Terminal;

        COMMIT;
        CurFrame.SendUserEvent (EventName = 'LoadObject_D1',
                                MessageInteger = D1.O.Object);
        CurFrame.SendUserEvent (EventName = 'LoadObject_D2',
                                MessageInteger = D2.O.Object);
    END;

ON Click D2_Disconnect =

    BEGIN
        i = FIELD(D2.T).CurRow;

        IF i = 0 THEN
            INSERT INTO GrassCatcher (Object, Problem)
                VALUES (:D2.O.Object, 'Object_010');
            ROLLBACK;
            RESUME;
        ENDIF;

        UPDATE  Terminal T
        SET     Node = :Node$Floating
        WHERE   :D2.T[].Object = T.Object AND
                :D2.T[].Terminal = T.Terminal;

        COMMIT;
        CurFrame.SendUserEvent (EventName = 'LoadObject_D1',
                                MessageInteger = D1.O.Object);
        CurFrame.SendUserEvent (EventName = 'LoadObject_D2',
                                MessageInteger = D2.O.Object);
    END;
```

```
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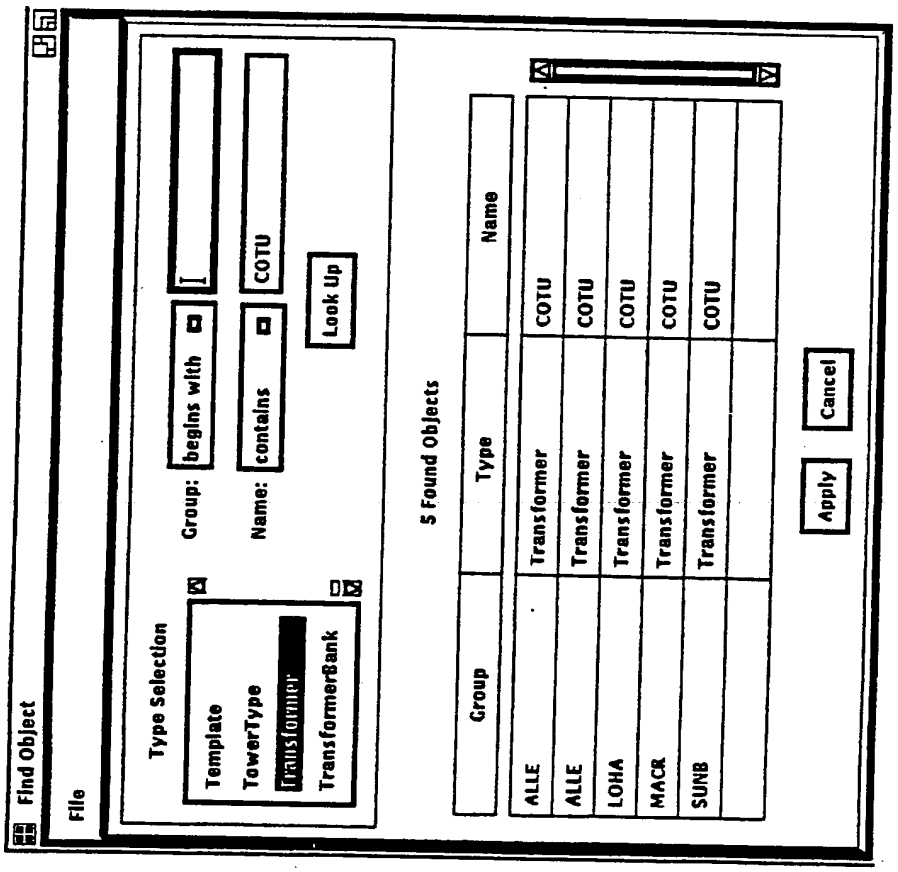
*****************************************************************************/

/*
**      Application:      PowerSystemModel
**      Frame:            Menu.File.CloseButton
*/
ON UserEvent 'Close',
ON Click Menu.File.CloseButton =

    BEGIN
        CurFrame.WindowVisibility = WV_Invisible;
    END;
```



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*****************************************************************************/

/*
 *      Application:    PowerSystemModel
 *      Frame:          FindObject
 *
 *      This frame can be called to find an object. The types of objects
 *      that will be presented may be restricted by passing a supertype
 *      to this frame - only the subtypes of this type will be shown for
 *      selection.
 *
 *      The caller frame can also pass its frame identifier, the name of
 *      a user event and (optionally) an integer. If these are passed,
 *      then the selections made by the user are communicated to the caller
 *      by sending user events with the given name and integer and a message
 *      object of type ObjectSummaryClass. If the caller frame does not
 *      pass the frame identifier and event name, this frame returns with
 *      the user selection in an ObjectSummaryClass.
 */
INITIALIZE
    (
    SuperType = INTEGER NOT NULL;                   /* Passed super type for menu */
    CallerFrame = FrameExec;                        /* Passed calling frame */
    CallerEvent = VARCHAR(32);                      /* Passed return event to caller
    CallerInteger = INTEGER;                        /* Passed info for caller */
    i = INTEGER NOT NULL;                           /* Scratch integer */
    Type = TypeClass;                               /* Scratch type */
    FO_Title = VARCHAR(32) NOT NULL;                /* Title for FO table field */
    F_GroupingName_Pattern = VARCHAR(22);           /* Pattern for filter name */
    F_ObjectName_Pattern = VARCHAR(22);             /* Pattern for filter name */
    )=
    BEGIN
/*
 *      Set up a list of all the types for the user to use as a filter
 */
        FIELD(F_Type).ValueList.ChoiceItems.Clear();
        i = 1;

        IF SuperType = 0 THEN
            F_Type = Type$Object;
        ELSE
            F_Type = SuperType;
        ENDIF;

        REPEATED
        SELECT   :Type.Type = T.Type,
                 :Type.Name = T.Name
        FROM     Type T,
                 ExtendedType ET
```

```
        WHERE    :F_Type = ET.SuperType AND
                 ET.Type = T.Type AND
                 T.BaseType != 0          /* Ignore "for classification only" */
        ORDER BY Name
        BEGIN
            FIELD(F_Type).ValueList.ChoiceItems[i].EnumText = Type.Name;
            FIELD(F_Type).ValueList.ChoiceItems[i].EnumValue = Type.Type;
            i = i + 1;
        END;

        ROLLBACK;
/*
 *      Save the original title of the table field
 */
        FO_Title = FIELD(FO).Title;
    END;
```

```
ON Click LookUp =
/*
 *
 */
    BEGIN
        FIELD(FO).Title = FO_Title;
        FO.Clear();
        i = 1;
/*
 *      Set up the pattern for the GroupingName match based on the selection.
 */
        IF F_GroupWild = 0 THEN
            F_GroupingName_Pattern = F_GroupingName;
        ELSEIF F_GroupWild = 1 THEN
            F_GroupingName_Pattern = '%' + F_GroupingName + '%';
        ELSEIF F_GroupWild = 2 THEN
            F_GroupingName_Pattern = F_GroupingName + '%';
        ELSEIF F_GroupWild = 3 THEN
            F_GroupingName_Pattern = '%' + F_GroupingName;
        ENDIF;
/*
 *      Set up the pattern for the ObjectName match based on the selection.
 */
        IF F_ObjectWild = 0 THEN
            F_ObjectName_Pattern = F_ObjectName;
        ELSEIF F_ObjectWild = 1 THEN
            F_ObjectName_Pattern = '%' + F_ObjectName + '%';
        ELSEIF F_ObjectWild = 2 THEN
            F_ObjectName_Pattern = F_ObjectName + '%';
        ELSEIF F_ObjectWild = 3 THEN
            F_ObjectName_Pattern = '%' + F_ObjectName;
        ENDIF;

        REPEATED
        SELECT  :FO[i].Object = O.Object,
                :FO[i].BaseType = O.BaseType,
                :FO[i].Type = O.Type,
                :FO[i].PrimaryGrouping = O.PrimaryGrouping,
                :FO[i].TypeName = O.TypeName,
                :FO[i].Name = O.Name,
                :FO[i].PrimaryGroupingName = O.PrimaryGroupingName
        FROM    Object O
        WHERE   O.PrimaryGroupingName LIKE :F_GroupingName_Pattern AND
                O.Name LIKE :F_ObjectName_Pattern AND
                O.Type IN
                    (
                    SELECT  ET.Type
                    FROM    ExtendedType ET
                    WHERE   :F_Type = ET.SuperType
                    )
        ORDER BY
                PrimaryGroupingName,
                TypeName,
                Name
        BEGIN
            i = i + 1;
        END;

        FIELD(FO).Title = VARCHAR(i - 1) + ' ' + FO_Title;
        ROLLBACK;
    END;
```

```
ON Click Apply_Button =
/*
 *      Pass the selected object (if any) back to the caller
 */
    BEGIN

        IF FIELD(FO).ActiveRow != 0 THEN

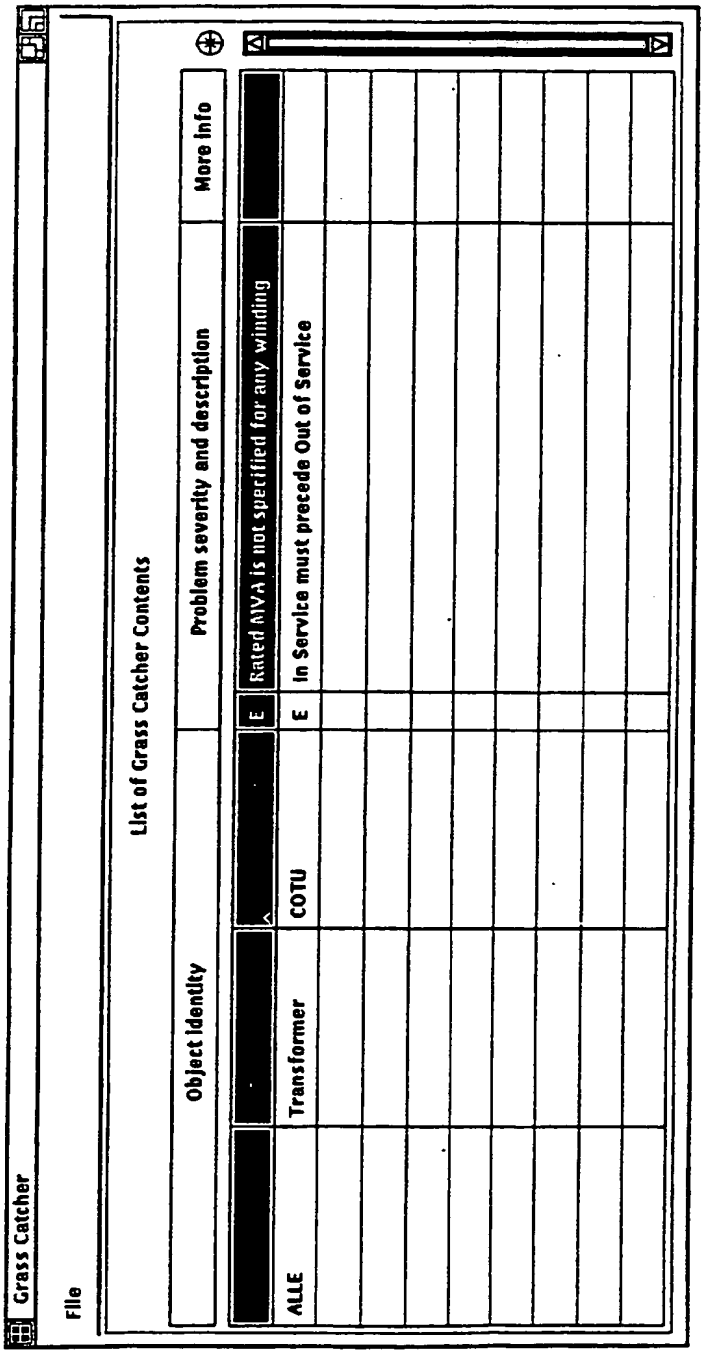
            IF CallerEvent = '' THEN
                RETURN FO[];
            ELSE
                CallerFrame.SendUserEvent (EventName = CallerEvent
                                          ,MessageObject = FO[].Duplicate()
                                          ,MessageInteger = CallerInteger
                                          );
            ENDIF;

        ENDIF;

    END;

ON Click Cancel_Button =
/*
 *      Done for now
 */
    BEGIN
        RETURN NULL;
    END;

ON ChildProperties FO =
/*
 *      Edit the selected object
 */
    BEGIN
        IF FIELD(FO).ActiveRow != 0 THEN
            CALLPROC ObjectEditor (OS = FO[]);
        ENDIF;
    END;
```



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*****************************************************************************/

/*
 *          Application:   PowerSystemModel
 *          Frame:         GrassCatcher
 */
INITIALIZE
    (
    i = INTEGER NOT NULL;                          /* Scratch integer */
    SGC = GrassCatcherClass;                       /* Scratch grass catcher */
    )=
    BEGIN
        i = 1;

        SELECT  :GC[i].Object = GC.Object,
                :GC[i].Problem = GC.Problem,
                :GC[i].Text = GC.Text,
                :GC[i].O.Object = O.Object,
                :GC[i].O.BaseType = O.BaseType,
                :GC[i].O.Type = O.Type,
                :GC[i].O.PrimaryGrouping = O.PrimaryGrouping,
                :GC[i].O.TypeName = O.TypeName,
                :GC[i].O.Name = O.Name,
                :GC[i].O.PrimaryGroupingName = O.PrimaryGroupingName,
                :GC[i].P.Problem = P.Problem,
                :GC[i].P.Severity = P.Severity,
                :GC[i].P.Description = P.Description
        FROM    GrassCatcher GC,
                Object O,
                Problem P
        WHERE   GC.Object = O.Object AND
                GC.Problem = P.Problem
        ORDER BY
                PrimaryGroupingName,
                TypeName,
                Name
        BEGIN
            i = i + 1;
        END;

        ROLLBACK;
    END;
```

```
ON DeleteRow GC =
/*
 *      Wipe out all matching entries
 */
    BEGIN
        IF FIELD(GC).ActiveRow != 0 THEN
            SGC = GC[].Duplicate();

            DELETE FROM GrassCatcher GC
            WHERE   :SGC.Object = GC.Object AND
                    :SGC.Problem = GC.Problem;

            i = GC.LastRow();

            WHILE i > 0 DO

                IF GC[i].Object = SGC.Object AND
                   GC[i].Problem = SGC.Problem THEN
                    GC.RemoveRow (RowNumber = i);
                ENDIF;

                i = i - 1;
            ENDWHILE;

            COMMIT;
        ENDIF;

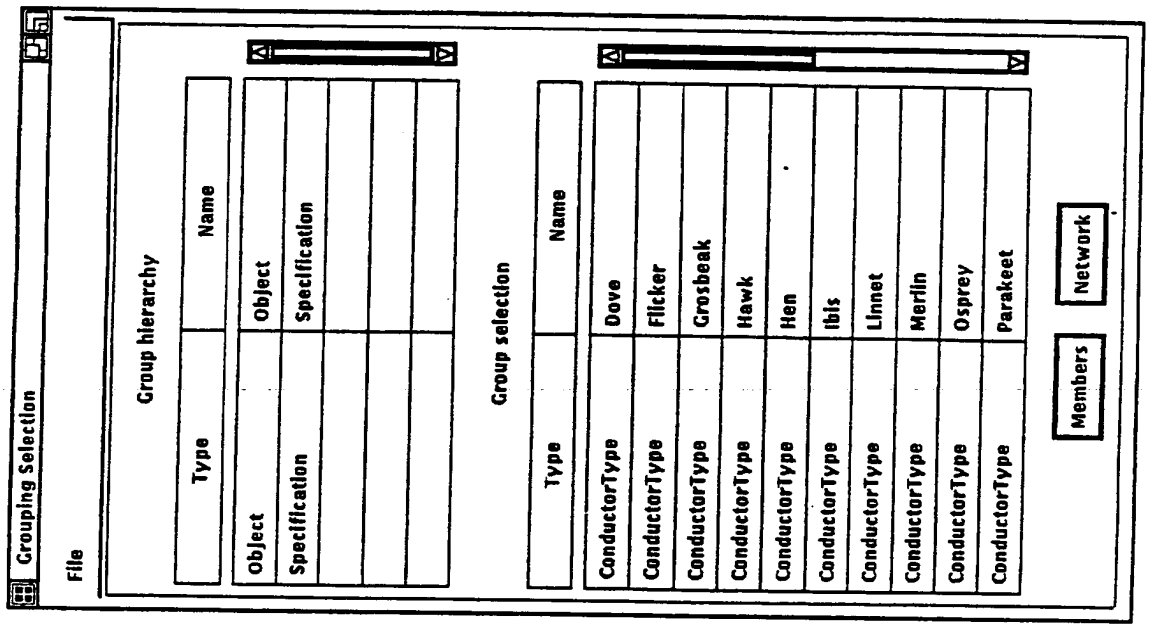
    END;

ON ClearTable GC =
/*
 *      Nuke the whole schmeer; throw in a quick MODIFY to reclaim space
 */
    BEGIN
        DELETE FROM GrassCatcher;
        MODIFY GrassCatcher TO Btree
            ON Object, Problem;

        GC.Clear();

        COMMIT;
    END;

ON ChildProperties GC =
/*
 *      Edit the selected object
 */
    BEGIN
        IF FIELD(GC).ActiveRow != 0 THEN
            CALLPROC ObjectEditor (OS = GC[].O);
        ENDIF;
    END;
```



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*****************************************************************************/

/*
**      Application:  PowerSystemModel
**      Frame:        GroupingSelection
*/
INITIALIZE
    (
    i = INTEGER;                                    /* Scratch integer */
    MenuEntry = ChoiceItem;                         /* Scratch menu entry */
    FrameName = VARCHAR(20) NOT NULL;               /* Editor frame name */
    ObjectSummary = ObjectSummaryClass;             /* Object summary */
    )=
    BEGIN
/*
 *      Set up the top level "grouping" and load up its members
 */
        GH.Clear();

        GH[1].Object = 0;
        GH[1].BaseType = 0;
        GH[1].Type = 0;
        GH[1].PrimaryGrouping = 0;
        GH[1].TypeName = 'Object';
        GH[1].Name = 'Object';
        GH[1].PrimaryGroupingName = 'Object';

        ObjectSummary = GH[1];
        CurFrame.SendUserEvent (EventName = 'GSLoadData');
    END;

ON UserEvent 'GSLoadData' =

    BEGIN
/*
 *      Get the members of the selected group object
 */
        GS.Clear ();
        i = 1;

        REPEATED
        SELECT  :GS[i].Object = O.Object,
                :GS[i].BaseType = O.BaseType,
                :GS[i].Type = O.Type,
                :GS[i].PrimaryGrouping = O.PrimaryGrouping,
                :GS[i].TypeName = O.TypeName,
                :GS[i].Name = O.Name,
                :GS[i].PrimaryGroupingName = O.PrimaryGroupingName
        FROM    Object O,
```

```
            Grouping G
    WHERE   :ObjectSummary.Object = G.Grouping AND
            :Type$Member_of = G.Relationship AND
            G.Member = O.Object
    ORDER BY
            TypeName,
            Name
    BEGIN
        i = i + 1;
    END;

    ROLLBACK;
END;
```

```
ON ChildEntry GH =

    BEGIN
        IF FIELD(GH).CurRow != 0 THEN
            ObjectSummary = GH[];
/*
 *        Remove the entries lower down the hierarchy
 */
            i = GH.LastRow();

            WHILE i > FIELD(GH).CurRow DO
                GH.RemoveRow(RowNumber = i);
                i = i - 1;
            ENDWHILE;

            CurFrame.SendUserEvent (EventName = 'GSLoadData');
        ENDIF;
    END;

ON ChildDetails GS,
ON Click Members =

    BEGIN
        IF FIELD(GS).ActiveRow != 0 THEN
            ObjectSummary = GS[];
/*
 *        Add the selected row to the end of the heirarchy
 */
            i = GH.LastRow();
            GH[i + 1] = GS[].Duplicate();
            CurFrame.SendUserEvent (EventName = 'GSLoadData');
        ENDIF;
    END;

ON ChildProperties GS =

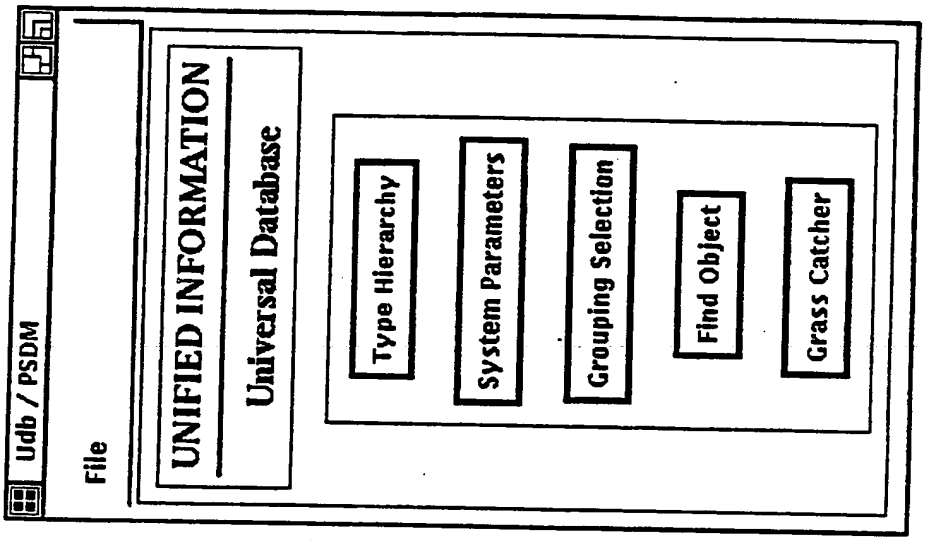
    BEGIN
        IF FIELD(GS).CurRow != 0 THEN
            CALLPROC ObjectEditor (OS = GS[]);
        ENDIF;
    END;

ON Click Network =

    BEGIN
        IF FIELD(GS).CurRow != 0 THEN
            GlobalFrame[Frame$ConnectivityEditor].Frame.SendUserEvent
                (EventName = 'LoadObject_D1', MessageInteger = GS[].Object);
        ENDIF;
    END;

ON Details Network =

    BEGIN
        IF FIELD(GS).CurRow != 0 THEN
            GlobalFrame[Frame$ConnectivityEditor].Frame.SendUserEvent
                (EventName = 'LoadObject_D2', MessageInteger = GS[].Object);
        ENDIF;
    END;
```



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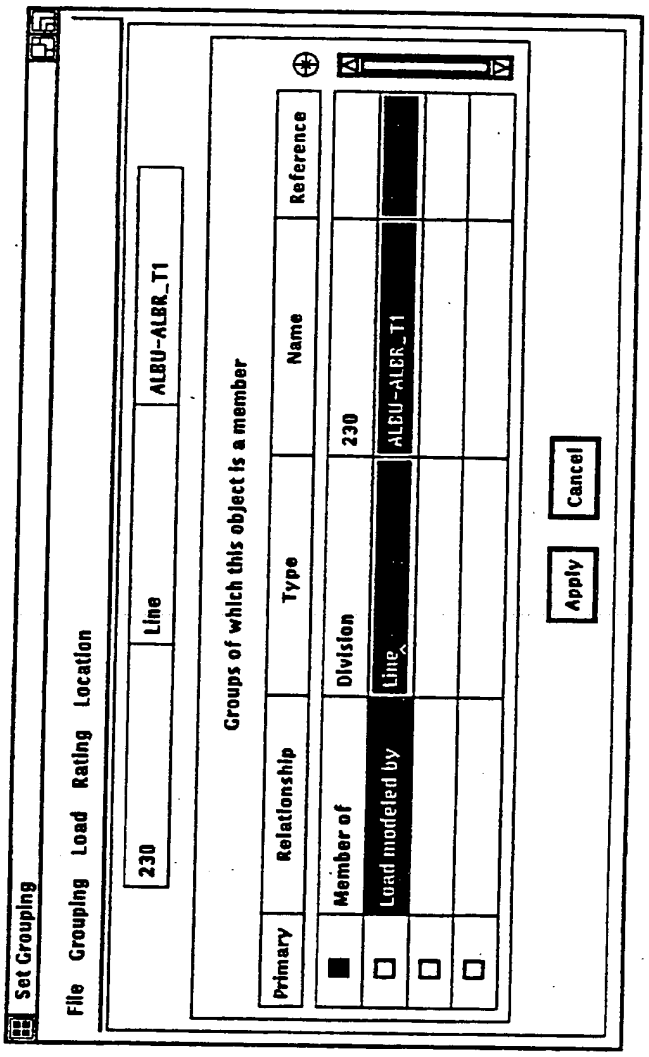
 *****************************************************************************/

/*
**        Application:  PowerSystemModel
**        Frame:        PSM
*/
INITIALIZE
    (
    )=
    BEGIN
/*
**        Set up the global variables from the database
*/
       SELECT   :SP.Frequency = SP.Frequency,
                :SP.MVABase = SP.MVABase,
                :SP.KVReference = SP.KVReference,
                :SP.LengthRatio = SP.LengthRatio,
                :SP.GroundResistivity = SP.GroundResistivity,
                :SP.Temperature = SP.Temperature
        FROM    SystemParameters SP;

        CurFrame.SendUserEvent (EventName = 'StartGlobalFrames');
        ROLLBACK;
    END;

ON UserEvent 'StartGlobalFrames' =
    BEGIN
/*
 *      Start up all the global frames that the editors can use. Do this
 *      in subscript order so that the array extends correctly.
 */
        GlobalFrame[Frame$ConnectivityEditor].Frame = OPENFRAME ConnectivityEdi
    END;

ON ChildClick B =
    BEGIN
        CALLFRAME :CurFrame.TriggerField.Name;
    END;
```



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        52.227-19, as applicable.

 *****************************************************************************/

/*
**      Application:    PowerSystemModel
**      Frame:          SetGrouping
*/
INITIALIZE
    (
    Object = ObjectClass;                       /* Object being edited */
    OG = ARRAY OF GroupingClass;                /* Passed groupings */
    Relationship = INTEGER NOT NULL;            /* Relationship being added */
    i = INTEGER NOT NULL;                       /* Scratch integer */
    CList = ChoiceList;                         /* Scratch choice list entry */
    Type = TypeClass;                           /* Scratch type */
    OS = ObjectSummaryClass;                    /* Scratch Object summary */
    )=
    BEGIN
/*
 *      Show the object being worked on
 */
        LO.Object = Object.Object;
        LO.BaseType = Object.BaseType;
        LO.Type = Object.Type;
        LO.PrimaryGrouping = Object.PrimaryGrouping;
        LO.TypeName = Object.TypeName;
        LO.Name = Object.Name;
        LO.PrimaryGroupingName = Object.PrimaryGroupingName;
/*
 *      Load up the relationship (interaction) list
 */
        CALLPROC LoadTypeList
            (EF = EnumField(FIELD(MG[*].Relationship).ProtoField)
            ,StartType = Type$Interaction
            );
/*
 *      Get the names for the grouping objects and set the
 *      primary grouping marker
 */
        MG = OG.Duplicate();
        i = 1;
        WHILE i <= MG.LastRow() DO
            REPEATED
            SELECT  :MG[i].GO.Object = GO.Object,
                    :MG[i].GO.BaseType = GO.BaseType,
                    :MG[i].GO.Type = GO.Type,
                    :MG[i].GO.PrimaryGrouping = GO.PrimaryGrouping,
                    :MG[i].GO.TypeName = GO.TypeName,
                    :MG[i].GO.Name = GO.Name,
                    :MG[i].GO.PrimaryGroupingName = GO.PrimaryGroupingName
```

```
        FROM    Object GO
        WHERE   :MG[i].Grouping = GO.Object;

        IF MG[i].Grouping = Object.PrimaryGrouping THEN
            MG[i].Primary = 1;
        ELSE
            MG[i].Primary = 0;
        ENDIF;

        FIELD(MG[i].Primary).HasDataChanged = FALSE;
        i = i + 1;
    ENDWHILE;

    ROLLBACK;
END;
```

```
On Click Menu.Grouping.Member_of =
    BEGIN
        OPENFRAME FindObject
            (SuperType = Type$Object
            ,CallerFrame = CurFrame
            ,CallerEvent = 'AddSelection'
            ,CallerInteger = Type$Member_of
            ) WITH
            WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Grouping.Made_by =
    BEGIN
        OPENFRAME FindObject
            (SuperType = Type$Manufacturer
            ,CallerFrame = CurFrame
            ,CallerEvent = 'AddSelection'
            ,CallerInteger = Type$Made_by
            ) WITH
            WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Grouping.Shown_on =
    BEGIN
        OPENFRAME FindObject
            (SuperType = Type$Drawing
            ,CallerFrame = CurFrame
            ,CallerEvent = 'AddSelection'
            ,CallerInteger = Type$Shown_on
            ) WITH
            WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Load.Load_modeled_by =
    BEGIN
        OPENFRAME FindObject
            (SuperType = Type$Consumer
            ,CallerFrame = CurFrame
            ,CallerEvent = 'AddSelection'
            ,CallerInteger = Type$Load_modeled_by
            ) WITH
            WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Load.Load_family =
    BEGIN
        OPENFRAME FindObject
            (SuperType = Type$LoadFamily
            ,CallerFrame = CurFrame
            ,CallerEvent = 'AddSelection'
            ,CallerInteger = Type$Load_modeled_by
            ) WITH
            WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Load.Self =
    BEGIN
        CurFrame.SendUserEvent (EventName = 'AddSelection'
                               ,MessageObject = LO
                               ,MessageInteger = Type$Load_modeled_by
                               );
    END;

On Click Menu.Rating.Rated_as =
    BEGIN
```

```
        OPENFRAME FindObject
             (SuperType = LO.BaseType
             ,CallerFrame = CurFrame
             ,CallerEvent = 'AddSelection'
             ,CallerInteger = Type$Rated_as
             ) WITH
             WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Rating.Rating_family =
    BEGIN
        OPENFRAME FindObject
             (SuperType = Type$RatingFamily
             ,CallerFrame = CurFrame
             ,CallerEvent = 'AddSelection'
             ,CallerInteger = Type$Rated_as
             ) WITH
             WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Rating.Self =
    BEGIN
        CurFrame.SendUserEvent (EventName = 'AddSelection'
                               ,MessageObject = LO
                               ,MessageInteger = Type$Rated_as
                               );
    END;

On Click Menu.Location.Located_with =
    BEGIN
        OPENFRAME FindObject
             (SuperType = Type$Object
             ,CallerFrame = CurFrame
             ,CallerEvent = 'AddSelection'
             ,CallerInteger = Type$Located_with
             ) WITH
             WindowTitle = MenuButton(CurFrame.OriginatorField).TextLabel;
    END;

On Click Menu.Location.Self =
    BEGIN
        CurFrame.SendUserEvent (EventName = 'AddSelection'
                               ,MessageObject = LO
                               ,MessageInteger = Type$Located_with
                               );
    END;
```

```
ON UserEvent 'AddSelection' =
/*
 *      Add the selection to the members' group list
 */
    BEGIN
        OS = ObjectSummaryClass(CurFrame.MessageObject);
        Relationship = CurFrame.MessageInteger;
        i = 1;

        WHILE i <= MG.LastRow() DO

            IF MG[i].Grouping = OS.Object AND
               MG[i].Relationship = Relationship THEN
                INSERT INTO GrassCatcher (Object, Problem)
                    VALUES (OS.Object, 'Object_011');
                ROLLBACK;
                RESUME;
            ENDIF;

            i = i + 1;
        ENDWHILE;

        MG[i].Primary = 0;
        FIELD(MG[i].Primary).HasDataChanged = FALSE;
        MG[i].GO = OS.Duplicate();
        MG[i].Grouping = OS.Object;
        MG[i].GroupingType = OS.Type;
        MG[i].Relationship = Relationship;
        MG[i].Reference = '';
    END;
```

```
ON ChildSetValue MG[*].Primary =
/*
 *      If this is being set, ensure it is the only one; set the active
 *      row to the one being selected.
 */
    BEGIN
        i = 1;

        WHILE i <= MG.LastRow() DO

            IF FIELD(MG[i].Primary).HasDataChanged = TRUE THEN
                FIELD(MG).ActiveRow = i;
            ELSE
                MG[i].Primary = 0;
            ENDIF;

            FIELD(MG[i].Primary).HasDataChanged = FALSE;
            i = i + 1;
        ENDWHILE;

    END;

ON ChildProperties MG =
/*
 *      Edit the selected object
 */
    BEGIN
        IF FIELD(MG).ActiveRow != 0 THEN
            CALLPROC ObjectEditor (OS = MG[].GO);
        ENDIF;
    END;

ON ChildDetails MG =
/*
 *      Show the details of the association
 */
    BEGIN
        IF FIELD(MG).ActiveRow != 0 THEN
            IF MG[].Relationship = Type$Member_of THEN
                /* No details to show */
            ELSEIF MG[].Relationship = Type$Made_by THEN
                /* No details to show */
            ELSEIF MG[].Relationship = Type$Shown_on THEN
                /* No details to show */
            ELSEIF MG[].Relationship = Type$Load_modeled_by THEN
                CALLFRAME SetLoadCurve (Object = MG[].Grouping);
            ELSEIF MG[].Relationship = Type$Rated_as THEN
                CALLFRAME SetRating (Object = MG[].Grouping);
            ELSEIF MG[].Relationship = Type$Located_with THEN
                CALLFRAME SetLocation (Object = MG[].Grouping);
            ENDIF;

        ENDIF;
    END;
```

```
ON Click Apply_Button =
/*
 *      Ensure that the objects' primary group is set correctly and
 *      pass back the modified list
 */
    BEGIN
        Object.PrimaryGrouping = 0;
        Object.PrimaryGroupingName = '';
        i = 1;
        OG.Clear();

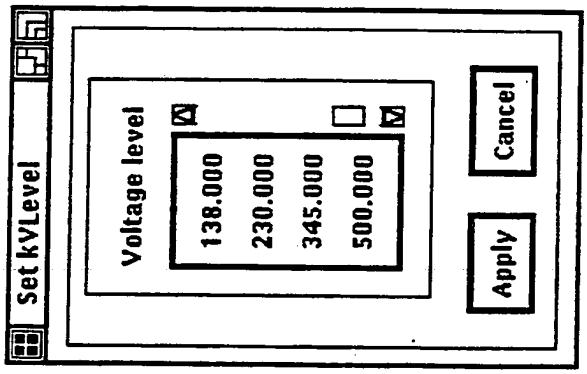
        WHILE i <= MG.LastRow() DO

            IF MG[i].Primary = 1 THEN
                Object.PrimaryGrouping = MG[i].Grouping;
                Object.PrimaryGroupingName = MG[i].GO.Name;
            ENDIF;

            OG[i] = MG[i].Duplicate();
            i = i + 1;
        ENDWHILE;

        RETURN;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN;
    END;
```


Set kVLevel
Voltage level
138.000
230.000
345.000
500.000
Cancel
Apply

```
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 *****************************************************************************/

/*
 *        Application:  PowerSystemModel
 *        Frame:        SetKVLevel
 */
INITIALIZE
    (
    kVLevel = FLOAT NOT NULL;                /* Passed kVLevel */
    Voltage = ARRAY OF FloatObject;          /* Defined voltages */
    i = INTEGER NOT NULL;                    /* Scratch integer */
    )=
    BEGIN
/*
 *      Set up a list of all the kVLevels
 */
        FIELD(F_kVLevel).ValueList.ChoiceItems.Clear();
        i = 1;

        SELECT  :Voltage[i].Value = kV.kVLevel
        FROM    kVLevel kV
        ORDER BY Value
        BEGIN
            FIELD(F_kVLevel).ValueList.ChoiceItems[i].EnumText =
                VARCHAR (Voltage[i].Value);
            FIELD(F_kVLevel).ValueList.ChoiceItems[i].EnumValue = i;

            IF Voltage[i].Value = kVLevel THEN
                F_kVLevel = i;
            ENDIF;

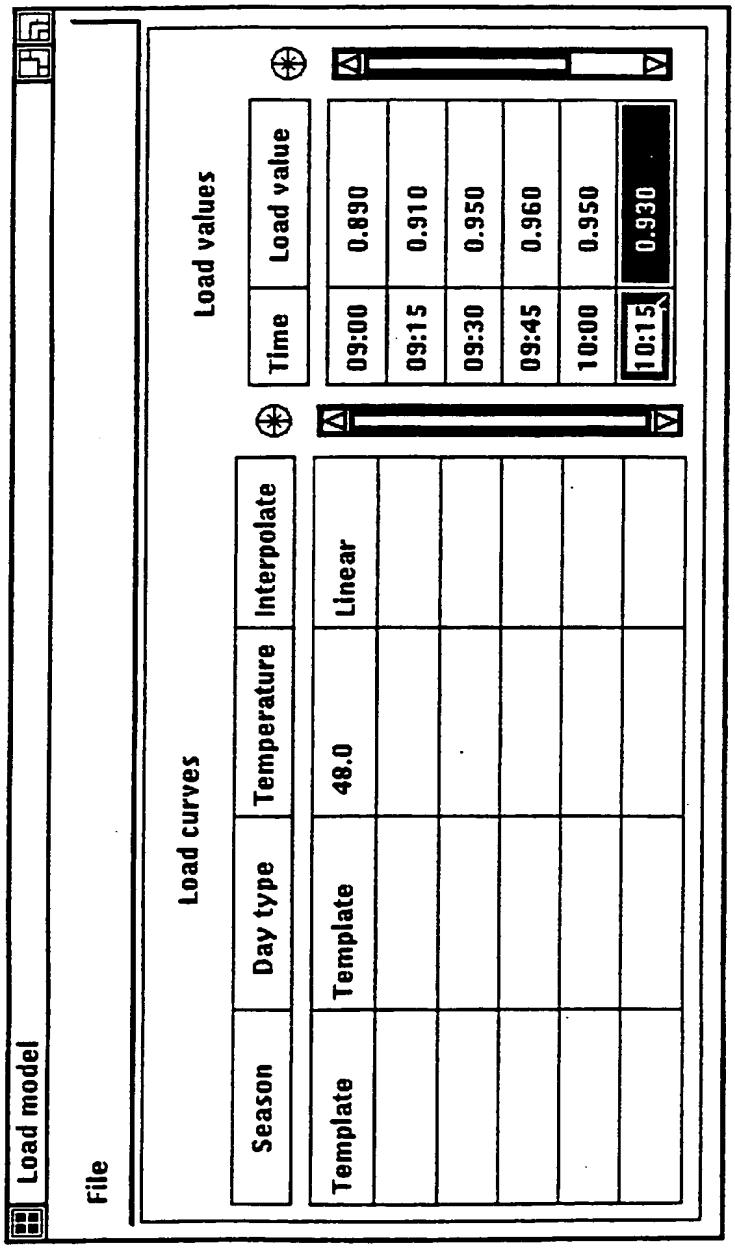
            i = i + 1;
        END;

        ROLLBACK;
    END;
```

```
ON Click Apply_Button =
/*
 *      Pass the selected voltage level back to the caller
 */
    BEGIN
        RETURN Voltage[F_kVLevel].Value;
    END;

ON Click Cancel_Button =
/*
 *      Pass the original voltage level back to the caller
 */
    BEGIN
        RETURN kVLevel;
    END;
```

202



```
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*****************************************************************************/

/*
 *      Application:  PowerSystemModel
 *      Frame:        SetLoadCurve
 */
INITIALIZE
    (
    Object = INTEGER NOT NULL;                  /* Passed object */
    i = INTEGER NOT NULL;                       /* Scratch integer */
    Season = ObjectSummaryClass;                /* Scratch season */
    DayType = ObjectSummaryClass;               /* Scratch day type */
    CList = ChoiceList;                         /* Reference to choice list */
    )=
    BEGIN
/*
 *      Set up the Season list
 */
        CList = EnumField(FIELD(LC[*].Season).ProtoField).ValueList;
        CList.ChoiceItems.Clear();
        CList.ChoiceItems[1].EnumValue = 0;
        CList.ChoiceItems[1].EnumText = '';
        i = 2;

        REPEATED
        SELECT  :Season.Object = S.Object,
                :Season.Name = S.Name
        FROM    Object S
        WHERE   :Type$Season = S.Type
        ORDER BY Name
        BEGIN
            CList.ChoiceItems[i].EnumValue = Season.Object;
            CList.ChoiceItems[i].EnumText = Season.Name;
            i = i + 1;
        END;

        EnumField(FIELD(LC[*].Season).ProtoField).UpdChoiceList();
/*
 *      Set up the DayType list
 */
        CList = EnumField(FIELD(LC[*].DayType).ProtoField).ValueList;
        CList.ChoiceItems.Clear();
        CList.ChoiceItems[1].EnumValue = 0;
        CList.ChoiceItems[1].EnumText = '';
        i = 2;

        REPEATED
        SELECT  :DayType.Object = DT.Object,
                :DayType.Name = DT.Name
```

```
            FROM    Object DT
            WHERE   :Type$DayType = DT.Type
            ORDER BY Name
            BEGIN
                CList.ChoiceItems[i].EnumValue = DayType.Object;
                CList.ChoiceItems[i].EnumText = DayType.Name;
                i = i + 1;
            END;

            EnumField(FIELD(LC[*].DayType).ProtoField).UpdChoiceList();
/*
 *      Load up the load curves from the passed object
 */
            i = 1;

            REPEATED
            SELECT  :LC[i].Object = LC.Object,
                    :LC[i].DayType = LC.DayType,
                    :LC[i].Season = LC.Season,
                    :LC[i].Temperature = LC.Temperature,
                    :LC[i].LoadCurve = LC.LoadCurve,
                    :LC[i].Source = LC.Source,
                    :LC[i].Interpolate = LC.Interpolate
            FROM    LoadCurve LC
            WHERE   :Object = LC.Object
            BEGIN
                i = i + 1;
            END;

            ROLLBACK;
        END;

    ON ChildEntry LC =
/*
 *      Display the list of values for the load curve
 */
        BEGIN
            i = 1;
            REPEATED
            SELECT  :LV[i].LoadCurve = LV.LoadCurve,
                    :LV[i].Time = LV.Time,
                    :LV[i].LoadValue = LV.LoadValue
            FROM    LoadValue LV
            WHERE   :LC[].LoadCurve = LV.LoadCurve
            BEGIN
                i = i + 1;
            END;

            ROLLBACK;
        END;

    ON ChildProperties LV =
/*
 *      Draw a graph of the load values
 */
        BEGIN
            CALLFRAME LoadCurveGraph (LV = LV);
        END;
```

```
INITIALIZE
(
    LV = ARRAY OF LoadValueClass;

    Xmax = INTEGER NOT NULL;
    Ymax = INTEGER NOT NULL;
    Xseg = FLOAT NOT NULL;
    Yseg = FLOAT NOT NULL;
    NextSegment = SegmentShape;

    LastX = INTEGER NOT NULL;
    LastY = INTEGER NOT NULL;
    NewX = INTEGER NOT NULL;
    NewY = INTEGER NOT NULL;

    Time = INTEGER NOT NULL;
    i = INTEGER NOT NULL;
) =
BEGIN
    Xmax = FIELD(load_subform).Width;
    Ymax = FIELD(load_subform).Height;

    Xseg = Xmax / 1440.0;                    /* Minutes per day */
    Yseg = Ymax / 2.0;                       /* Load value range */

/* calculate the data points and line segments */

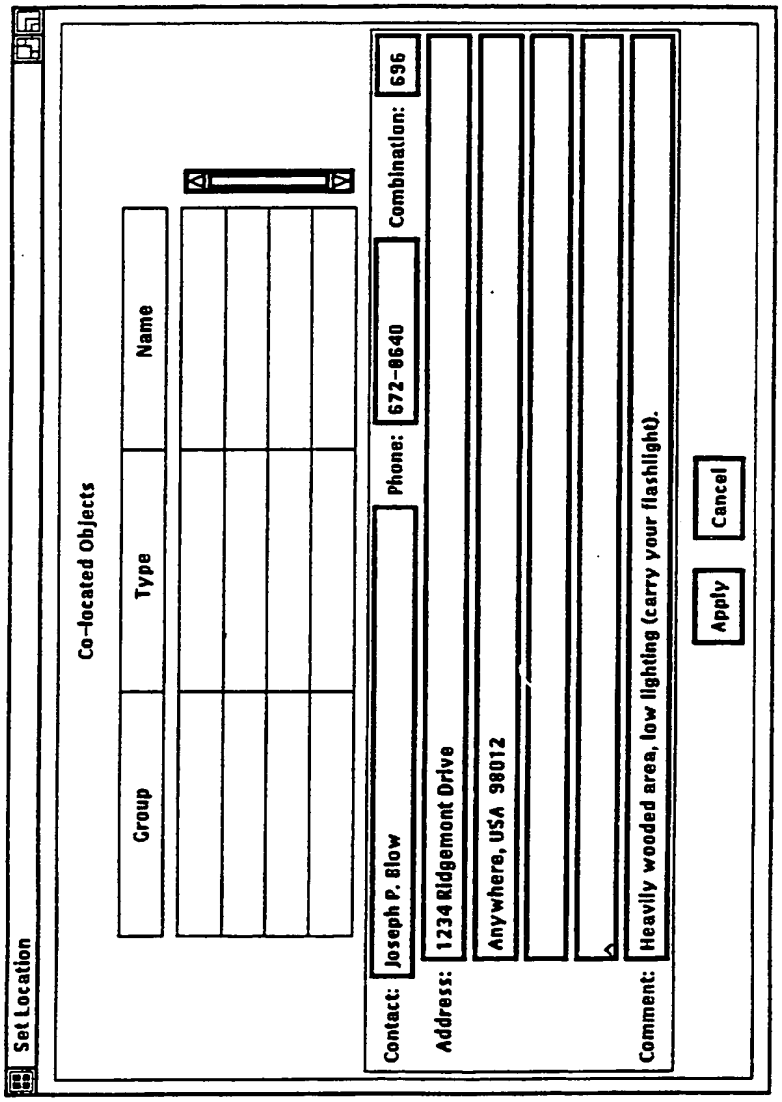
    i=1;

    WHILE i <= LV.LastRow() DO
        Time = DATE_PART ('hours', LV[i].Time) * 60;
        Time = Time + DATE_PART ('minutes', LV[i].Time);
        NewX = Xseg * Time;
        NewY = Ymax - (Yseg * LV[i].LoadValue);

        IF i > 1 THEN
            NextSegment = SegmentShape.Create();
            NextSegment.SetEndPoints(
                                Point1X = lastx,
                                Point1Y = lasty,
                                Point2X = newx,
                                Point2Y = newy);
            NextSegment.LineWidth = LW_VERYTHIN;
            NextSegment.LineColor = CC_LIGHT_BLUE;
            NextSegment.ParentFIELD = FIELD(load_subform);
        ENDIF;

        LastX = NewX;
        LastY = NewY;
        i = i + 1;
    ENDWHILE;

END;
```



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 *****************************************************************************/

/*
 *        Application:  PowerSystemModel
 *        Frame:        SetLocation
 */
INITIALIZE
    (
    Object = INTEGER;                                   /* Passed object */
    i = INTEGER NOT NULL;                               /* Scratch integer */
    )=
    BEGIN
/*
 *      Build the list of co-located objects
 */
        CO.Clear();
        i = 1;

        REPEATED
        SELECT  :CO[i].Object = CO.Object,
                :CO[i].BaseType = CO.BaseType,
                :CO[i].Type = CO.Type,
                :CO[i].PrimaryGrouping = CO.PrimaryGrouping,
                :CO[i].Name = CO.Name,
                :CO[i].TypeName = CO.TypeName,
                :CO[i].PrimaryGroupingName = CO.PrimaryGroupingName
        FROM    Object CO,
                Grouping G
        WHERE   :Object = G.Grouping AND
                :Type$Located_with = G.Relationship AND
                G.Member = CO.Object
        BEGIN
            i = i + 1;
        END;
/*
 *      Set up the location description. Ensure that if there isn't one
 *      in the database, then the object reference is set to null and the
 *      last used text is left so that it can be edited.
 */
        L.Object = Object$Null;

        REPEATED
        SELECT  :L.Object = L.Object,
                :L.Combination = L.Combination,
                :L.Phone = L.Phone,
                :L.Contact = L.Contact,
                :L.L1 = L.L1,
                :L.L2 = L.L2,
                :L.L3 = L.L3,
```

```
            :L.L4 = L.L4,
            :L.Comment = L.Comment
    FROM    Location L
    WHERE   :Object = L.Object;

    ROLLBACK;
END;
```

```
ON Click Apply_Button =
/*
 *      Set up the location, if needed; then update it
 */
    BEGIN

        IF L.Object = Object$Null THEN
            INSERT INTO Location
                (Object
                )
            VALUES
                (:Object
                );
        ENDIF;

        UPDATE  Location L
        SET     Combination = :L.Combination,
                Phone = :L.Phone,
                Contact = :L.Contact,
                L1 = :L.L1,
                L2 = :L.L2,
                L3 = :L.L3,
                L4 = :L.L4,
                Comment = :L.Comment
        WHERE   :Object = L.Object;

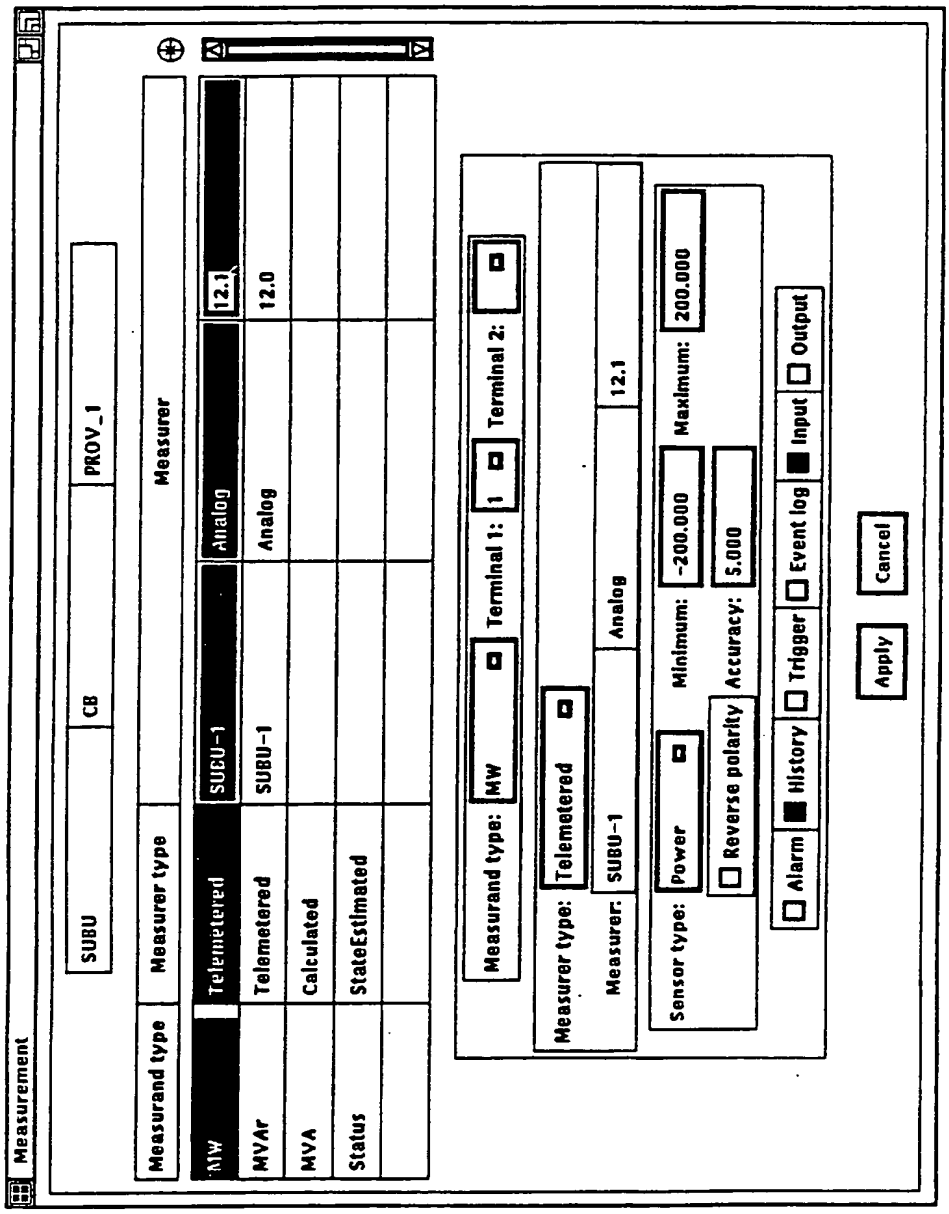
        COMMIT;
        RETURN;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN;
    END;

ON ChildProperties CO =
/*
 *      Edit the selected object
 */
    BEGIN

        IF FIELD(CO).CurRow != 0 THEN
            CALLPROC ObjectEditor (OS = CO[]);
        ENDIF;

    END;
```



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*****************************************************************************/

/*
**          Application:   PowerSystemModel
**          Frame:         SetMeasurment
*/
INITIALIZE
    (
    Object = ObjectClass;                          /* Object being edited */
    OM = ARRAY OF MeasurementClass;                /* Passed measurements */
    i = INTEGER NOT NULL;                          /* Scratch integer */
    Terminal = INTEGER NOT NULL;                   /* Scratch terminal number */
    CList = ChoiceList;                            /* Scratch choice list entry */
    )=
    BEGIN
        CurFrame.CurMode = FM_Query;
/*
 *      Show the object being worked on
 */
        O.Object = Object.Object;
        O.BaseType = Object.BaseType;
        O.Type = Object.Type;
        O.PrimaryGrouping = Object.PrimaryGrouping;
        O.TypeName = Object.TypeName;
        O.Name = Object.Name;
        O.PrimaryGroupingName = Object.PrimaryGroupingName;
/*
 *      Load up the type lists
 */
        CALLPROC LoadTypeList
            (EF = EnumField(FIELD(ML[*].MeasurandType).ProtoField)
            ,StartType = Type$Measurand
            );
        FIELD(M.MeasurandType).ValueList =
            EnumField(FIELD(ML[*].MeasurandType).ProtoField).ValueList;

        CALLPROC LoadTypeList
            (EF = EnumField(FIELD(ML[*].MeasurerType).ProtoField)
            ,StartType = Type$Measurer
            );
        FIELD(M.MeasurerType).ValueList =
            EnumField(FIELD(ML[*].MeasurerType).ProtoField).ValueList;

        CALLPROC LoadTypeList
            (EF = EnumField(FIELD(M.SensorType))
            ,StartType = Type$Sensor
            );
/*
 *      Load the lists of valid terminals for the object
```

```
*/
        CList = FIELD(M.Terminal1).ValueList;
        CList.ChoiceItems.Clear();
        CList.ChoiceItems[1].EnumValue = 0;
        CList.ChoiceItems[1].EnumText = '';
        i = 2;

        REPEATED
        SELECT DISTINCT
                :Terminal = T.Terminal
        FROM    Terminal T
        WHERE   :Object.Object = T.Object
        ORDER BY Terminal
        BEGIN
            CList.ChoiceItems[i].EnumValue = Terminal;
            CList.ChoiceItems[i].EnumText = VARCHAR(Terminal);
            i = i + 1;
        END;

        FIELD(M.Terminal1).UpdChoiceList();
        FIELD(M.Terminal2).ValueList = Clist;
        FIELD(M.Terminal2).UpdChoiceList();
/*
 *      Build the list of measurements made on this object.
 */
        ML = OM.Duplicate();
        i = 1;
        WHILE i <= ML.LastRow() DO
            REPEATED
            SELECT  :ML[i].MO.Object = MO.Object,
                    :ML[i].MO.BaseType = MO.BaseType,
                    :ML[i].MO.Type = MO.Type,
                    :ML[i].MO.PrimaryGrouping = MO.PrimaryGrouping,
                    :ML[i].MO.TypeName = MO.TypeName,
                    :ML[i].MO.Name = MO.Name,
                    :ML[i].MO.PrimaryGroupingName = MO.PrimaryGroupingName
            FROM    Object MO
            WHERE   :ML[i].Measurer = MO.Object;
            i = i + 1;
        ENDWHILE;

        ROLLBACK;
    END;

ON ChildEntry ML =
/*
 *      Edit a measurement
 */
    BEGIN
        M = ML[];
        CurFrame.CurMode = FM_Update;
    END;

ON ChildProperties ML =
/*
 *      Edit the selected object
 */
    BEGIN
        IF FIELD(ML).ActiveRow != 0 THEN

            IF ML[].Measurer != 0 THEN
                CALLPROC ObjectEditor (OS = ML[].MO);
            ENDIF;

        ENDIF;
    END;
```

```
ON ChildProperties M.MO =
    BEGIN
        IF M.Measurer != 0 THEN
            CALLPROC ObjectEditor (OS = M.MO);
        ENDIF;
    END;

ON ChildDetails M.MO =
    BEGIN
        OPENFRAME FindObject
            (SuperType = Type$Sensing
            ,CallerFrame = CurFrame
            ,CallerEvent = 'UpdateM.MO'
            ,CallerInteger = 0
            ) WITH
            WindowTitle = 'Find Measurer';
    END;

ON UserEvent 'UpdateM.MO' =
    BEGIN
        M.MO = ObjectSummaryClass(CurFrame.MessageObject).Duplicate();
        M.Measurer = M.MO.Object;
        FIELD(ML).UpdField();
    END;

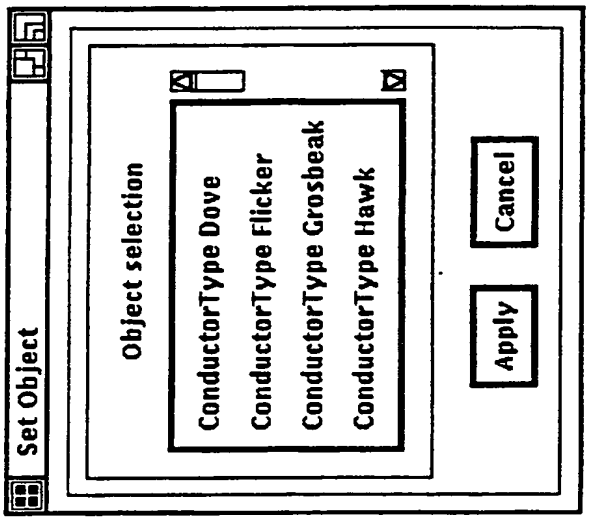
ON ChildSetValue M =
    BEGIN
        FIELD(ML).UpdField();
    END;

ON Click Apply_Button =
/*
 *      Pass back the modified list.
 */
    BEGIN
        i = 1;
        OM.Clear();

        WHILE i <= ML.LastRow() DO
            OM[i] = ML[i].Duplicate();
            i = i + 1;
        ENDWHILE;

        RETURN;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN;
    END;
```



```
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 *****************************************************************************/

/*
 *      Application:    PowerSystemModel
 *      Frame:          SetObject
 */
INITIALIZE
    (
    Type = INTEGER NOT NULL;                        /* Passed Type */
    DefaultObject = INTEGER NOT NULL;               /* Passed default object */
    i = INTEGER NOT NULL;                           /* Scratch integer */
    s = VARCHAR(80) NOT NULL;                       /* Scratch string */
    OS = ObjectSummaryClass;                        /* Scratch Object */
    )=
    BEGIN
/*
 *      Set up a list of all the Objects for the user to use as a filter
 */
        FIELD(F_Object).ValueList.ChoiceItems.Clear();
        i = 1;

        REPEATED
        SELECT  :OS.Object = O.Object,
                :OS.PrimaryGroupingName = O.PrimaryGroupingName,
                :OS.TypeName = O.TypeName,
                :OS.Name = O.Name
        FROM    Object O,
                ExtendedType ET
        WHERE   :Type = ET.SuperType AND
                ET.Type = O.Type
        ORDER BY PrimaryGroupingName, TypeName, Name
        BEGIN
            s = OS.PrimaryGroupingName + ' ' + OS.TypeName + ' ' + OS.Name;
            s = Squeeze (s);
            FIELD(F_Object).ValueList.ChoiceItems[i].EnumText = s;
            FIELD(F_Object).ValueList.ChoiceItems[i].EnumValue = OS.Object;
            i = i + 1;
        END;

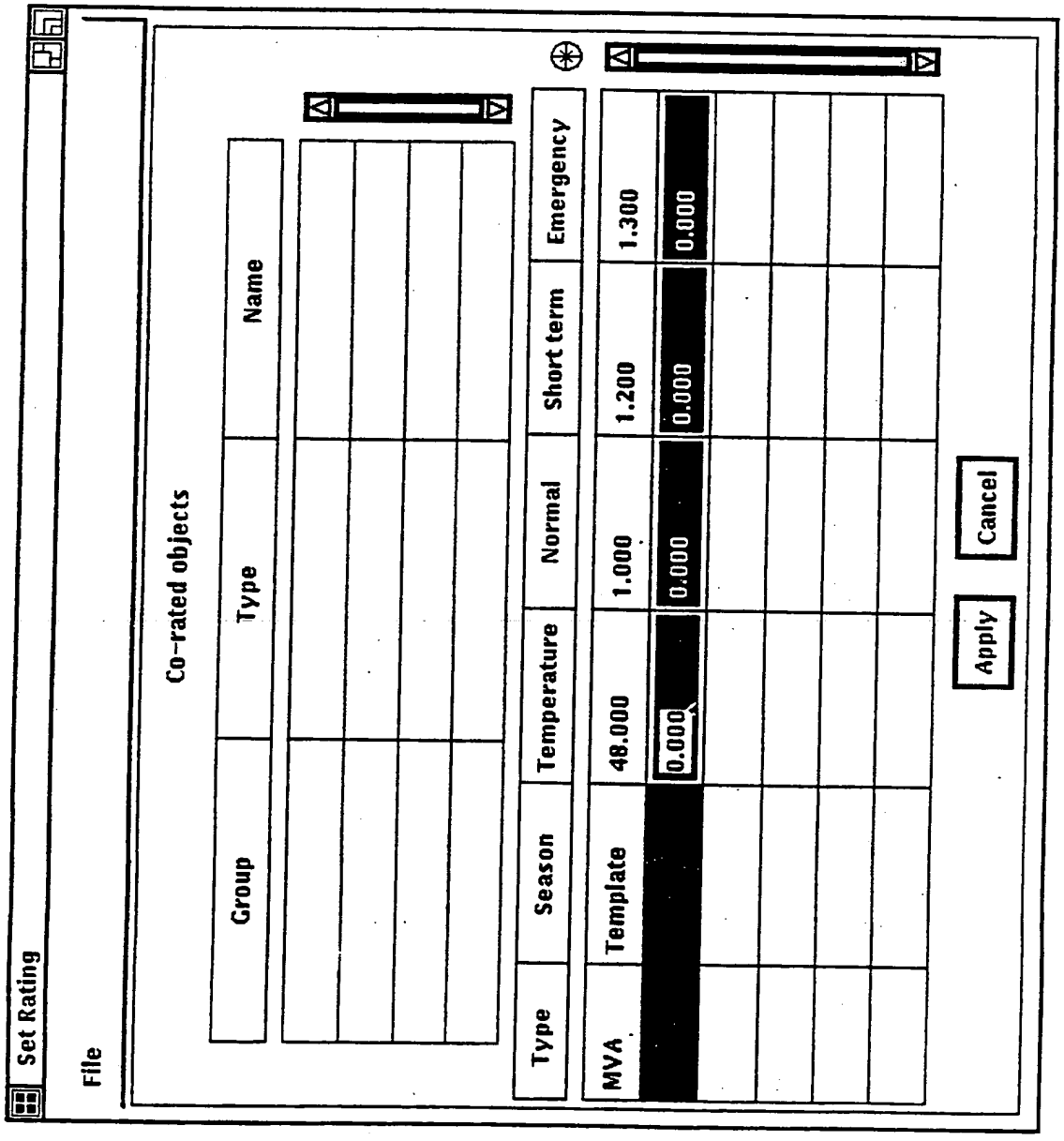
        F_Object = DefaultObject;
        ROLLBACK;
    END;
```

```
ON Click Apply_Button =
/*
 *      Pass the selected Object back to the caller
 */
    BEGIN
        RETURN F_Object;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN NULL;
    END;

ON Properties F_Object =
/*
 *      Edit the selected object
 */
    BEGIN
        IF F_Object != Object$Null THEN
            REPEATED
            SELECT  :OS.Object = O.Object,
                    :OS.BaseType = O.BaseType,
                    :OS.Type = O.Type,
                    :OS.PrimaryGrouping = O.PrimaryGrouping,
                    :OS.TypeName = O.TypeName,
                    :OS.Name = O.Name,
                    :OS.PrimaryGroupingName = O.PrimaryGroupingName
            FROM    Object O
            WHERE   :F_Object = O.Object;

            CALLPROC ObjectEditor (OS = OS);
        ENDIF;
    END;
```



```
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*****************************************************************************/

/*
 *        Application:   PowerSystemModel
 *        Frame:         SetRating
 */
INITIALIZE
    (
    Object = INTEGER;                                   /* Passed object */
    i = INTEGER NOT NULL;                               /* Scratch integer */
    Season = ObjectSummaryClass;                        /* Scratch season */
    SeasonList = ChoiceList;                            /* Reference to season list */
    )=
    BEGIN
/*
 *      Set up the Season list
 */
        SeasonList = EnumField(FIELD(R[*].Season).ProtoField).ValueList;
        SeasonList.ChoiceItems.Clear();
        SeasonList.ChoiceItems[1].EnumValue = 0;
        SeasonList.ChoiceItems[1].EnumText = '';
        i = 2;

        SELECT  :Season.Object = S.Object,
                :Season.Name = S.Name
        FROM    Object S
        WHERE   :Type$Season = S.Type
        ORDER BY Name
        BEGIN
            SeasonList.ChoiceItems[i].EnumValue = Season.Object;
            SeasonList.ChoiceItems[i].EnumText = Season.Name;
            i = i + 1;
        END;

        EnumField(FIELD(R[*].Season).ProtoField).UpdChoiceList();
/*
 *      Build the list of co-rated objects
 */
        CO.Clear();
        i = 1;

        REPEATED
        SELECT  :CO[i].Object = CO.Object,
                :CO[i].BaseType = CO.BaseType,
                :CO[i].Type = CO.Type,
                :CO[i].PrimaryGrouping = CO.PrimaryGrouping,
                :CO[i].Name = CO.Name,
                :CO[i].TypeName = CO.TypeName,
                :CO[i].PrimaryGroupingName = CO.PrimaryGroupingName
```

```
        FROM    Object CO,
                Grouping G
        WHERE   :Object = G.Grouping AND
                :TypeSRated_as = G.Relationship AND
                G.Member = CO.Object
        BEGIN
            i = i + 1;
        END;
/*
 *      Load up the ratings
 */
        R.Clear();
        i = 1;

        REPEATED
        SELECT  :R[i].Object = R.Object,
                :R[i].Type = R.Type,
                :R[i].Season = R.Season,
                :R[i].Temperature = R.Temperature,
                :R[i].Normal = R.Normal,
                :R[i].ShortTerm = R.ShortTerm,
                :R[i].Emergency = R.Emergency,
                :R[i].Loadshed = R.Loadshed
        FROM    Rating R
        WHERE   :Object = R.Object
        ORDER BY Type, Temperature
        BEGIN
            i = i + 1;
        END;

        ROLLBACK;
    END;
```

```
ON Click Apply_Button =
/*
 *      Blow the ratings away, and re-load them
 */
    BEGIN
        DELETE FROM Rating WHERE :Object = Object;

        i = 1;
        WHILE i <= R.LastRow() DO
            INSERT INTO Rating
                (Object
                ,Type
                ,Season
                ,Temperature
                ,Normal
                ,ShortTerm
                ,Emergency
                ,Loadshed
                )
            VALUES
                (:Object
                ,:R[i].Type
                ,:R[i].Season
                ,:R[i].Temperature
                ,:R[i].Normal
                ,:R[i].ShortTerm
                ,:R[i].Emergency
                ,:R[i].Loadshed
                );
            i = i + 1;
        ENDWHILE;

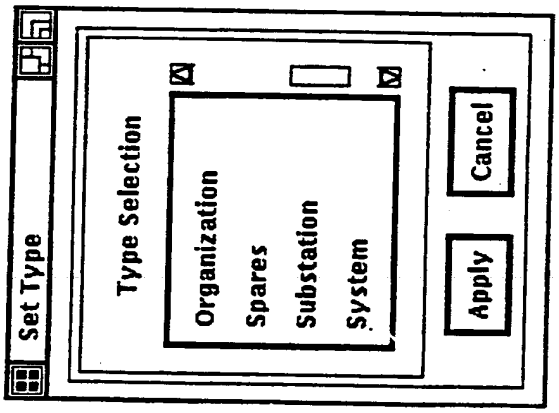
        COMMIT;
        RETURN;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN;
    END;

ON ChildProperties CO =
/*
 *      Edit the selected object
 */
    BEGIN

        IF FIELD(CO).CurRow != 0 THEN
            CALLPROC ObjectEditor (OS = CO[]);
        ENDIF;

    END;
```


Set Type
Type Selection
Organization
Spares
Substation
System
Cancel
Apply

```
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          52.227-19, as applicable.

*****************************************************************************/

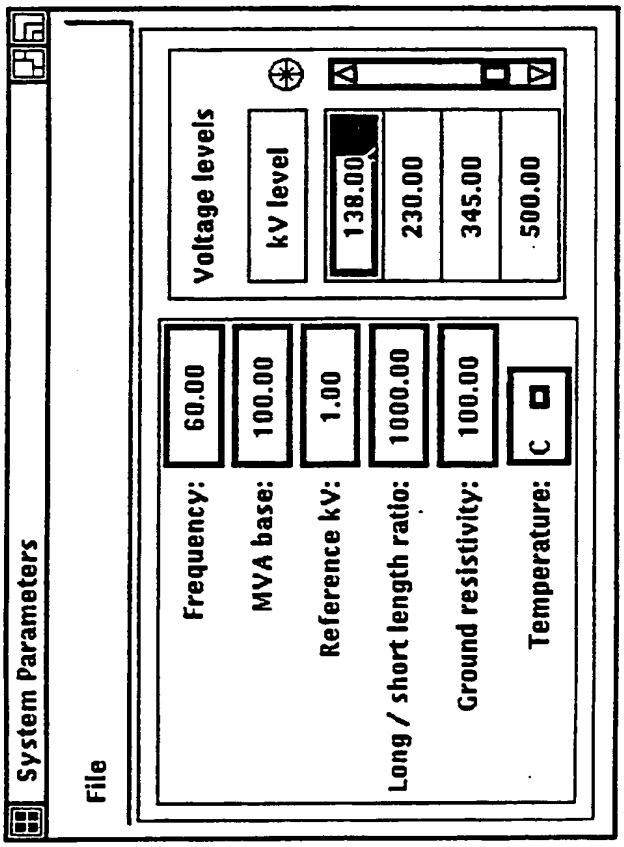
/*
 *        Application:  PowerSystemModel
 *        Frame:        FindType
 */
INITIALIZE
    (
    Object = ObjectClass;                          /* Passed object */
    i = INTEGER NOT NULL;                          /* Scratch integer */
    Type = TypeClass;                              /* Scratch type */
    )=
    BEGIN
/*
 *      Set up a list of all the types for the user to use as a filter
 */
        FIELD(F_Type).ValueList.ChoiceItems.Clear();
        i = 1;
        F_Type = Object.Type;

        REPEATED
        SELECT  :Type.Type = T.Type,
                :Type.Name = T.Name
        FROM    Type T,
                ExtendedType ET
        WHERE   :Object.BaseType = ET.SuperType AND
                ET.Type = T.Type
        ORDER BY Name
        BEGIN
            FIELD(F_Type).ValueList.ChoiceItems[i].EnumText = Type.Name;
            FIELD(F_Type).ValueList.ChoiceItems[i].EnumValue = Type.Type;
            i = i + 1;
        END;

        ROLLBACK;
    END;
```

```
ON Click Apply_Button =
/*
 *      Pass the selected type back to the caller
 */
    BEGIN
        Object.Type = F_Type;
        Object.TypeName = FIELD(F_Type).CurEnumText;
        RETURN;
    END;

ON Click Cancel_Button =
    BEGIN
        RETURN;
    END;
```



```
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 *****************************************************************************/

/*
**        Application:          PowerSystemModel
**        Frame:                SystemParameters
*/
INITIALIZE
    (
    i = INTEGER NOT NULL;                          /* Scratch integer */
    OriginalKV = ARRAY OF kVLevelClass;            /* Original values in table */
    )=

    BEGIN
/*
 *      Show the global copy of the system parameters
 */
        SPF = SP;
        CurFrame.SendUserEvent(EventName = 'LoadkVLevel');
    END;

ON UserEvent 'LoadkVLevel' =
    BEGIN
/*
 *        Get the kV levels and make a copy of the original values
 */
        kV.Clear();
        i = 1;

        REPEATED
        SELECT  :kV[i].kVLevel = kV.kVLevel
        FROM    kVLevel kV
        ORDER BY kVLevel
        BEGIN
            OriginalkV[i] = kV[i].Duplicate();
            i = i + 1;
        END;

        ROLLBACK;
    END;

ON ClearTable kV =
    BEGIN
        RESUME;
    END;

ON DeleteRow kV=
/*
 *      Attempt to delete the kVLevel entry, then re-load the table
 *      field so the user can see the current state of affairs.
```

```
*/
    BEGIN
        i = FIELD(kV).CurRow;

        DELETE FROM kVLevel kV
        WHERE   :OriginalkV[i].kVLevel = kV.kVLevel;

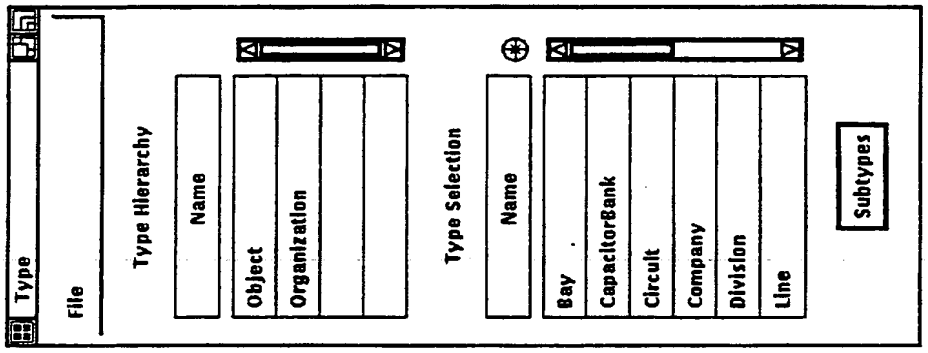
        COMMIT;
        CurFrame.SendUserEvent(EventName = 'LoadkVLevel');
    END;

ON InsertRow kV=
/*
 *      Add a new row in the same position in the "original" array and
 *      set the value to null.
 */
    BEGIN
        i = FIELD(kV).CurRow;
        OriginalkV.InsertRow (RowNumber = i);
        OriginalkV[i].kVLevel = NULL;
    END;

ON ChildSetValue kV =
/*
 *      Update the database immediately so that the user can
 *      get any feedback, then re-load the table
 *      field so they can see the current state of affairs.
 */
    BEGIN
        i = FIELD(kV).CurRow;

        IF OriginalkV[i].kVLevel IS NULL THEN
            INSERT INTO kVLevel
                (kVLevel
                ,Name
                ,Voltage
                )
            VALUES
                (:kV[i].kVLevel                 /**** fix up ****/
                ,VARCHAR(:kV[i].kVLevel)        /**** fix up ****/
                ,:kV[i].kVLevel                 /**** fix up ****/
                );
        ELSE
            UPDATE  kVLevel kV
            SET     kVLevel = :kV[i].kVLevel,       /**** fix up ****/
                    Name = VARCHAR(:kV[i].kVLevel), /**** fix up ****/
                    Voltage = :kV[i].kVLevel        /**** fix up ****/
            WHERE   :OriginalkV[i].kVLevel = kV.kVLevel;
        ENDIF;

        COMMIT;
        CurFrame.SendUserEvent(EventName = 'LoadkVLevel');
    END;
```


Type
File
Type Hierarchy
Name
Object
Organization
Type Selection
Name
Bay
CapacitorBank
Circuit
Company
Division
Line
Subtypes

```
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 *****************************************************************************/

/*
**        Application:  PowerSystemModel
**        Frame:        Type
*/
INITIALIZE
    (
    i = INTEGER;                                /* Scratch integer */
    Row = INTEGER;                              /* Scratch integer */
    ErrorNumber = INTEGER;                      /* Scratch integer */
    MenuEntry = ChoiceItem;                     /* Scratch menu entry */
    TypeName = VARCHAR(20);                     /* Local string variable */
    )=
    BEGIN
/*
 *      Set up the Type Hierarchy table field.
 */
        TH.Clear();
        SELECT  :TH[1].Type = T.Type,
                :TH[1].BaseType = T.BaseType,
                :TH[1].Name = T.Name
        FROM    Type T
        WHERE   T.Type = :Type$Object;
/*
 *      Set up the Type Selection table field.
 */
        i = 1;
        TS.Clear();
        SELECT  :TS[i].Type = T.Type,
                :TS[i].BaseType = T.BaseType,
                :TS[i].Name = T.Name
        FROM    Type T,
                SuperType ST
        WHERE   :TH[1].Type = ST.SuperType AND
                ST.Type = T.Type
        ORDER BY Name
        BEGIN
            i = i + 1;
        END;

        ROLLBACK;
    END;
```

```
ON ChildSetValue TS =
    BEGIN
/*
 *      Insert a new type and it's supertype if the key is undefined,
 *      otherwise update the existing entry.
 */
        IF TS[].Type = 0 THEN
            INSERT INTO Type
                (Type
                ,BaseType
                ,Name
                )
            VALUES
                (-1
                ,:TH[TH.LastRow()].BaseType
                ,:TS[].Name
                );
            INQUIRE_SQL( :ErrorNumber = ERRORNO );

            IF ErrorNumber != 0 THEN
                INSERT INTO GrassCatcher (Object, Text, Problem)
                    VALUES (0, :TS[].Name, 'Type_007');
                ROLLBACK;
                RESUME;
            ENDIF;

            SELECT  :TS[].Type = K.Value
            FROM    LastKey K
            WHERE   K.LastKey = 'Type';

            INSERT INTO SuperType
                (SuperType
                ,Type
                )
            VALUES
                (:TH[TH.LastRow()].Type
                ,:TS[].Type
                );
        ELSE
            UPDATE  Type T
            SET     Name = :TS[].Name
            WHERE   :TS[].Type = T.Type;
            INQUIRE_SQL( :ErrorNumber = ERRORNO );

            IF ErrorNumber != 0 THEN
                INSERT INTO GrassCatcher (Object, Text, Problem)
                    VALUES (0, :TS[].Name, 'Type_007');
                ROLLBACK;
                RESUME;
            ENDIF;
        ENDIF;

        COMMIT;
    END;
```

```
ON DeleteRow TS =
/*
 *  Delete the SuperType which points to this Type. Then delete the Type
 *  itself.
 */
    BEGIN

        DELETE FROM SuperType ST
        WHERE   :TS[].Type = ST.Type;

        INQUIRE_SQL( :ErrorNumber = ERRORNO );

        IF ErrorNumber = 0 THEN                          /* Query succeeded */

            DELETE FROM Type T
            WHERE   :TS[].Type = T.Type;

            INQUIRE_SQL( :ErrorNumber = ERRORNO );

            IF ErrorNumber = 0 THEN
                TS.RemoveRow(RowNumber = FIELD(TS).CurRow);
            ELSE
                ROLLBACK;
            ENDIF;

        ENDIF;

        COMMIT;
    END;

ON ClearTable TS =
    BEGIN
        RESUME;
    END;
```

```
ON ChildEntry TH =
/*
 *  Load the Type Selection table field with the subclasses of the selected
 *  type in the Type Hierarchy table field.
 *
 *  Never allow the TH table field to get input focus.
 */
    BEGIN
        Row = FIELD(TH).CurRow;

        i = 1;
        TS.Clear();
        REPEATED
        SELECT  :TS[i].Type = T.Type,
                :TS[i].BaseType = T.BaseType,
                :TS[i].Name = T.Name
        FROM    Type T,
                SuperType ST
        WHERE   :TH[Row].Type = ST.SuperType AND
                ST.Type = T.Type
        ORDER BY Name
        BEGIN
            i = i + 1;
        END;
/*
 *      Remove everything below the current row starting at the end.
 */
        Row = TH.LastRow();

        WHILE Row > FIELD(TH).CurRow DO
            TH.RemoveRow(RowNumber = Row);
            Row = Row - 1;
        ENDWHILE;

        ROLLBACK;
        RESUME;                         /* Throw away the rest of the events. */
    END;
```

```
ON ChildDetails TS,
ON Click SubClasses_Btn =
/*
 *  Load the Type Hierarchy table field with the superclass of the selected
 *  type in the Type Selection table field. Then reload the Type Selection
 *  table field with the subclasses of that Type Hierarchy table field entry.
 *
 */
    BEGIN

        IF FIELD(TS).CurRow = 0 THEN       /* If nothing is selected go away */
            ROLLBACK;
            RESUME;
        ENDIF;

        Row = TH.LastRow() + 1;
        TH[Row] = TS[].Duplicate(); /* Copy the TS entry to TH table field. */

        i = 1;
        TS.Clear();

        REPEATED
        SELECT   :TS[i].Type = T.Type,
                 :TS[i].BaseType = T.BaseType,
                 :TS[i].Name = T.Name
        FROM     Type T,
                 SuperType ST
        WHERE    :TH[Row].Type = ST.SuperType AND
                 ST.Type = T.Type
        ORDER BY Name
        BEGIN
            i = i + 1;
        END;

        ROLLBACK;
        RESUME;                          /* Throw away the rest of the events. */
    END;
```

CLAIMS

1. A method for creating an information model based on a physical system, comprising the steps of:

identifying all physical elements in a system;

creating an object table for said physical elements;

determining a set of attributes common to each object; and

grouping the objects by common attributes to establish a relationship between the elements which defines the physical system.

2. The method of claim 1, further comprising the steps of:

establishing a hierarchy of objects based on type relation among the objects.

3. The method of claim 2, wherein said hierarchy defines a type-supertype relationship.

4. The method of claim 1, wherein said object table creating step further comprises the step of:

assigning a unique surrogate key to each object by which said object is identified with said object table.

5. A method for creating a single source information model based on physical equipment in a power system, comprising the steps of:

identifying all physical equipment in the power system;

creating an object table for said physical equipment;

determining a set of attributes common to each object; and

grouping the objects by common attributes to establish

a relationship between the objects which defines the power system.

6. The method of claim 5, further comprising the step of:
assigning a unique surrogate key to each object by which the object is known in the object table.

7. The method of claim 5, further comprising:
establishing a defined user interface based on a window environment.

8. The method of claim 5, further comprising:
importing data from a proprietary database associated with a different system, such that a single point of maintenance is provided.

9. The method of claim 5, further comprising:
exporting data to a proprietary database associated with a different system, such that a single point of maintenance is provided.

10. The method of claim 5, further comprising:
assigning a network position identifier to selected objects which is independent of specific object attributes and which serves as a place holder within the power system model.

11. A method for creating a single source information model based on physical elements in a system, comprising the steps of:
creating an extensible type hierarchy;
identifying as objects said physical elements;
collapsing said objects into tables, where attributes

specific to all objects below base types are collapsed into type tables, and all objects above base types are collapsed into object tables, using a common object table with surrogate keys; and

externalizing and collapsing object relationships into tables, using typing to identify the type and relationship.

12. The method of claim 11, further comprising the step of:

allowing a user to extend said types down the hierarchy.

13. A single source information model based on physical equipment in a power system, comprising:

an object table, including a plurality of objects which identify all physical equipment in the power system, each object including a set of common attributes, said objects being grouped by said common attributes to establish a relationship between the objects which defines the power system.

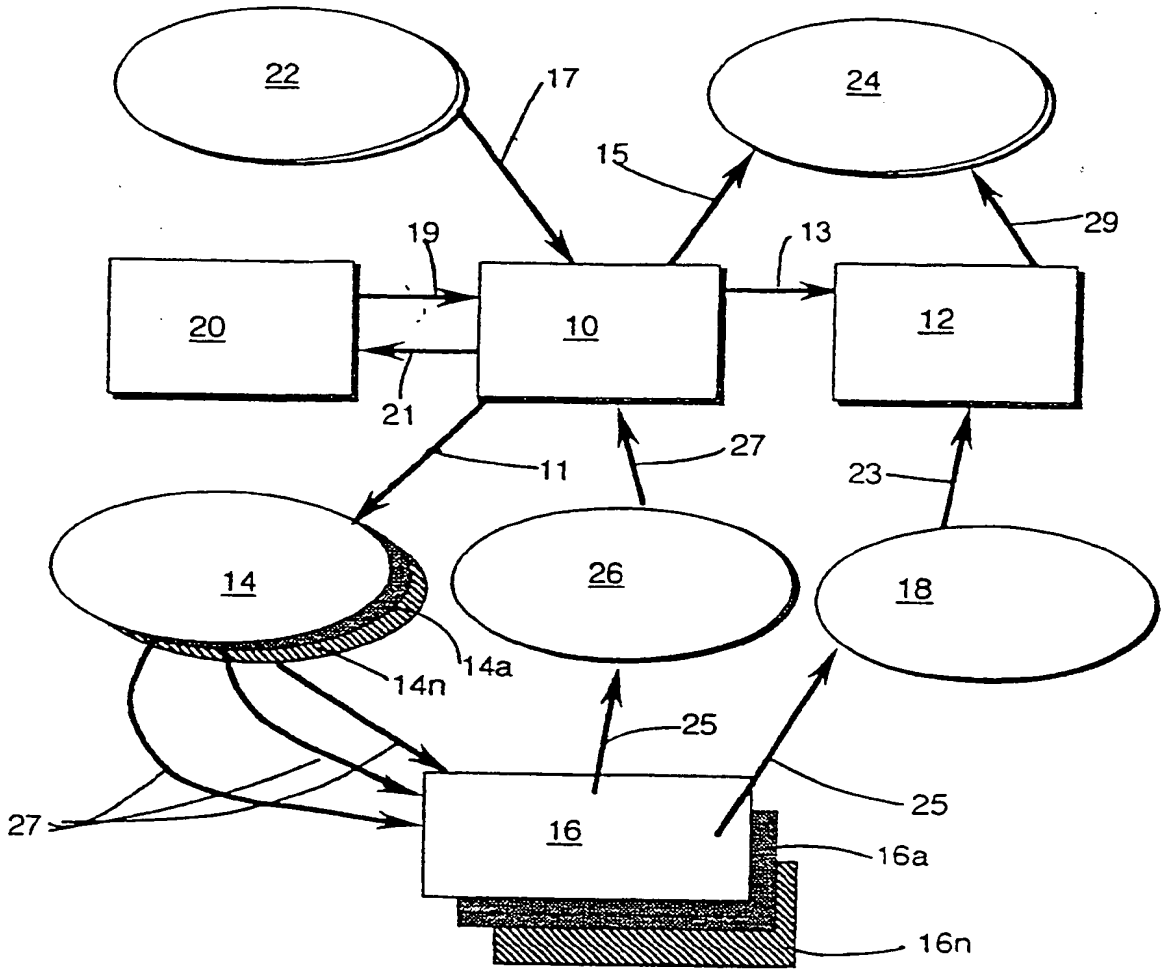


Fig. 1

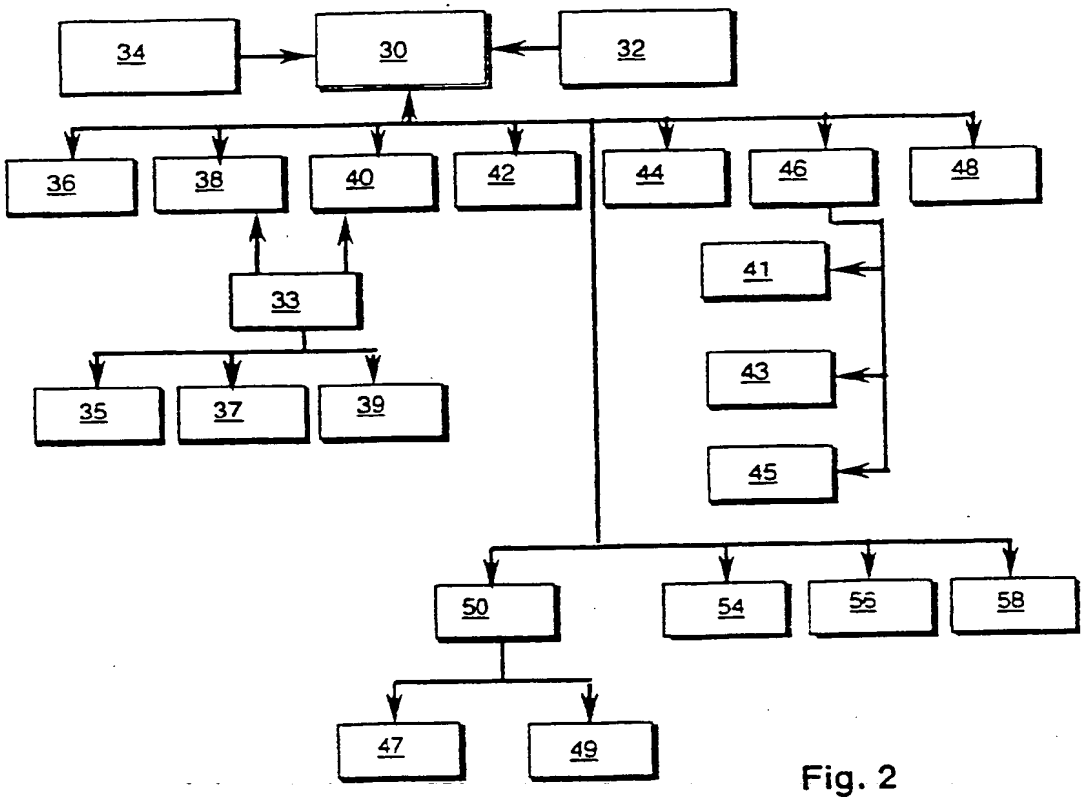


Fig. 2

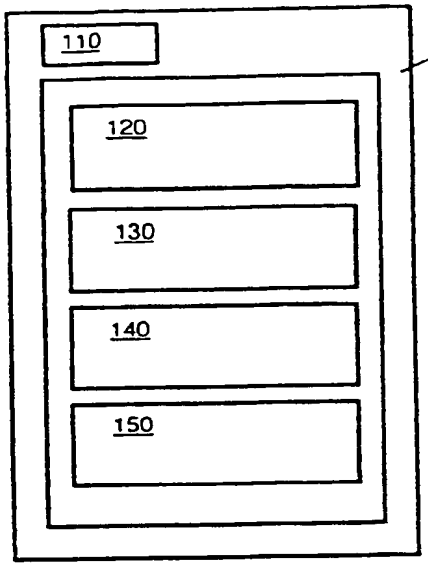


Fig. 3

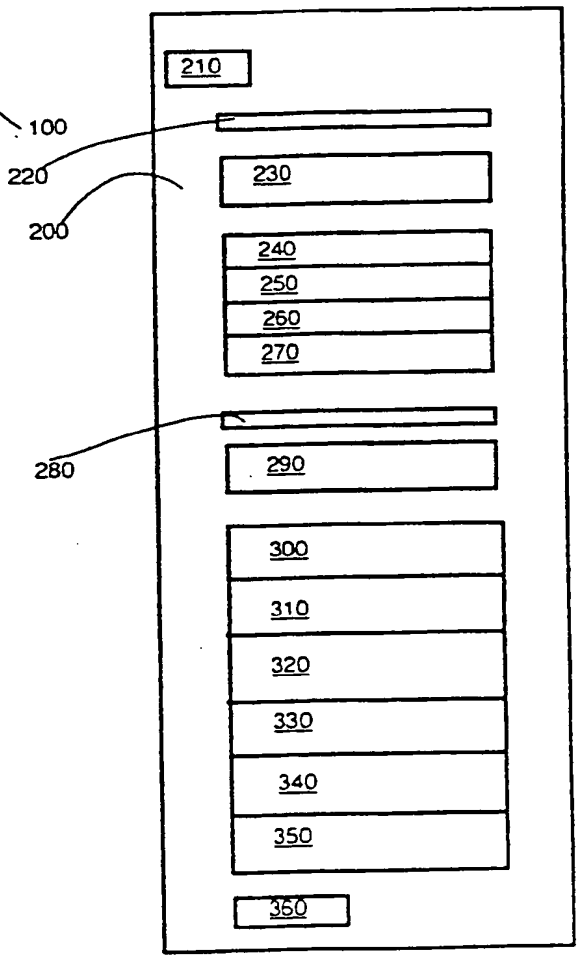
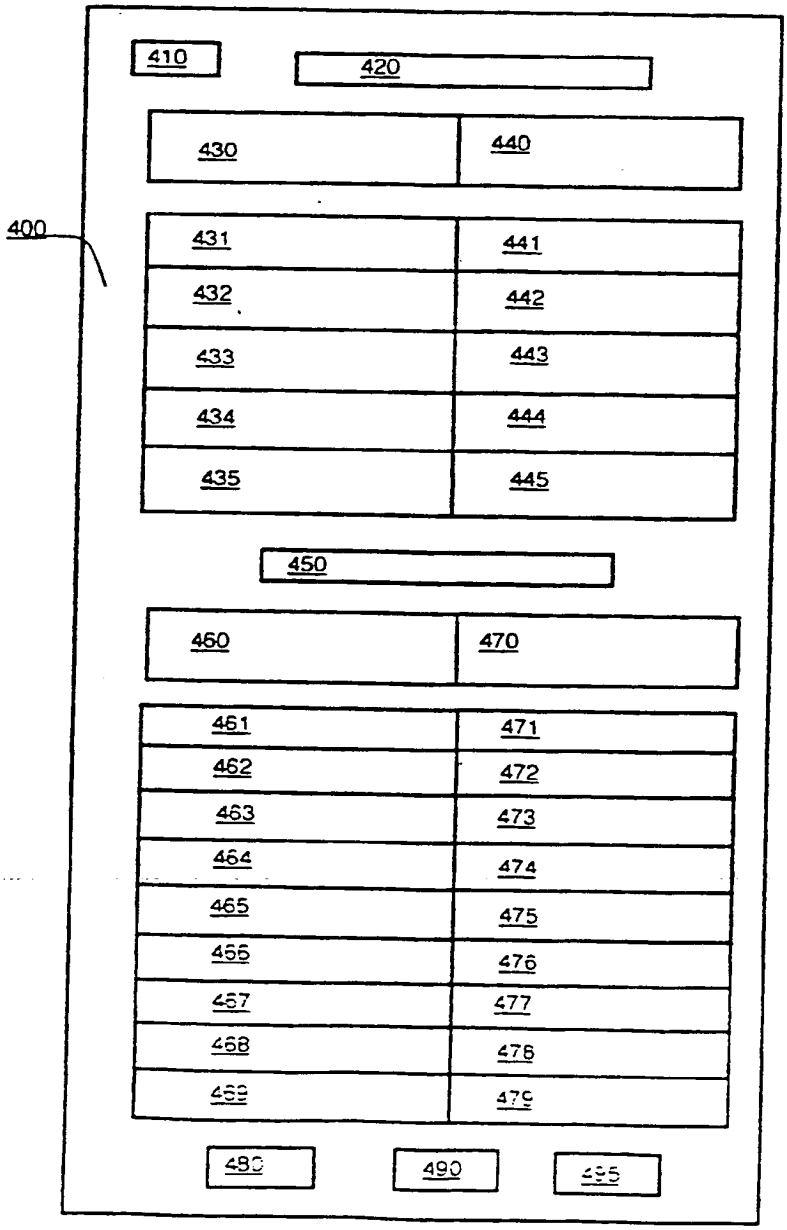


Fig. 4

Fig. 5



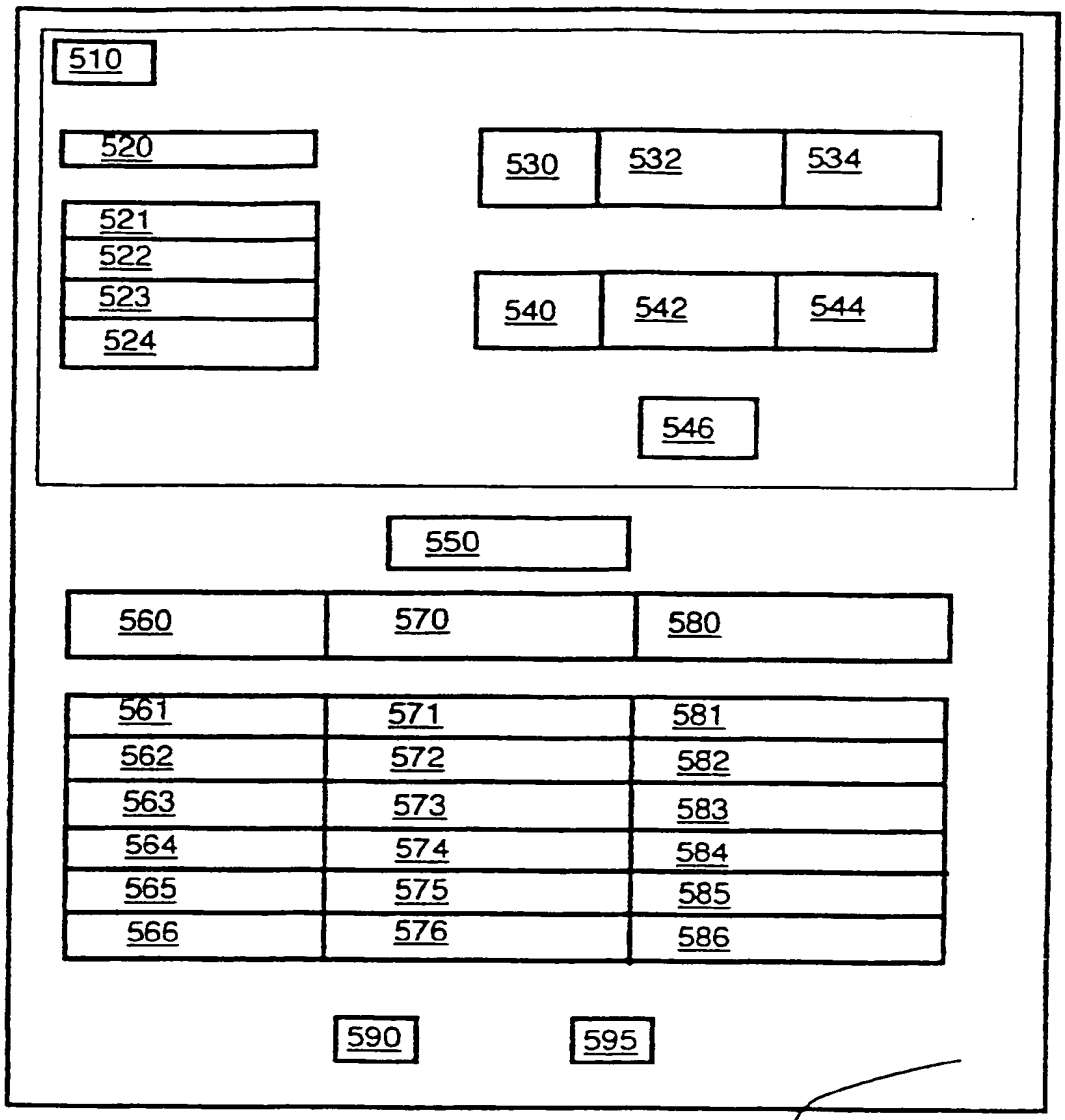


Fig. 6

INTERNATIONAL SEARCH REPORT

Int al Application No
PCT/US 93/08233

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G06F15/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ELEKTRONIK vol. 40, no. 22 , 29 October 1991 , GERMANY pages 122 - 134 C.J. KIEZULAS ET AL. 'Entwicklung von Expertensystemen. G2 - ein Tool für Echtzeit-Applikationen' see the whole document	1-13
X	PROCEEDINGS OF THE 2ND INTERNATIONAL CONFERENCE ON INDUSTRIAL AND ENGINEERING APPLICATIONS OF ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS (IEA/AIE) vol. 2 , 9 June 1989 , TULLAHOMA, TN, US pages 620 - 630 R. MOORE ET AL. 'Object Oriented rapid prototyping with G2' see the whole document	1-13

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[X] Further documents are listed in the continuation of box C. [ ] Patent family members are listed in annex.

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21 December 1993	06. 01. 94

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Katerbau, R

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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X	PROCEEDINGS OF THE 1991 IEEE INTERNATIONAL SYMPOSIUM ON INTELLIGENT CONTROL 15 August 1991 , ARLINGTON, VA, US pages 1 - 5 R. MOORE 'G2: A software platform for intelligent process control' see the whole document	1-13
X	SIMULATION AND AI, 1989, PROCEEDINGS OF THE SCS WESTERN MULTICONFERENCE vol. 20, no. 3 , 6 January 1989 , SAN DIEGO, CA, US pages 27 - 32 A.G. HOFMANN ET AL. 'Object Oriented models and their application in real-time expert systems' see the whole document	1-13

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